Why Do Rail Joints and Splice Bars Break?*

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When the first President of this Society presented to its members the first paper in the series of our periodical contributions, he framed its head lines in the interrogative mood, and affixed to its title an interrogation mark. The eminent propriety of this precedent has been amply acknowledged by subsequent contributors and I trust I too may be pardoned if I venture to present my paper this evening in the familiar shape of a conundrum.

When you desire information on a subject, of which you yourself are in ignorance, there is no better method of finding what you want to know than to read a paper and display your own want of knowledge regardless of all sacrifice of self-respect; this will encourage your audience to display unrestrainedly their own wisdom in the discussion, and will prove far more conducive to general enlightenment, than a too profuse exhibit of your own familiarity with your subject matter, which is apt to silence controversy and will cause your hearers to accept your own views as authority without question or dispute.

The subject upon which I would like to receive some information by means of the discussion which I trust the reading of this paper will bring forth, is this:

"Why do rail joints and splice bars break?"

This question must certainly seem simple enough, and no doubt finds a very ready answer in a general way to the effect, that if these splice bars and rail joints break, it is because they are incapable of resisting the strains which are brought upon them by the forces to which they are subjected. That is true enough as far as it goes; of course when we know the magnitude and direction of any acting forces we can readily determine their effect upon supports whose position and character are likewise known, and knowing the effect of the acting forces upon their supports and also knowing the resisting capacity of the materials composing the supports it would certainly seem that we ought to be able to devise their proper shape and determine the size necessary for the safe performance of the duty imposed.

Sometimes it happens, however, that the practical applications of theories apparently quite sound, produce results at variance with established principles which we have been accustomed to acknowledge as laws. In such cases a retrogressive force of reasoning from effect to cause, comes properly into play.

The splicing together of the rails of railway tracks has been accomplished by various means during the successive periods of railway construction. Commencing with the crude old fashioned wrought-iron lip chair these fastenings have undergone many changes and improvements, gradually tending towards a more rigid support and a more secure connection of the rail ends, resulting thereby in greater security and comfort to travel and in a less ruinous destruction of rolling stock. To refer even briefly to the endless variety of patented and unpatented contrivances and appliances invented for this purpose would consume more time than the most tolerant and patient of my hearers could be expected to concede.

I will therefore confine myself to a mere description of that particular device, which has of late found most favor among railroad men, and which in its general form has now the most extensive application upon the leading railroads of the country, varving of course, here and there in some minor and unimportant particulars.

This splice is the so-called angle bar joint; it consists of two rolled bars of the form shown on the sketch, Figs. 1 and 2, usually about 24 inches long, fitting closely under the head of the T rail and over its base, projecting just far enough outside of the foot of the rail to admit of receiving the slots for spiking the bars to the cross ties. The bars are punched for the bolts which pass through both angle bars and rail web, the punch holes for the inside bars being oblong to receive correspondingly shaped bolt heads and thus prevent the bolts from turning while being screwed up to a bearing; the diameters of the bolt holes are slightly larger than the bolts to allow for the maximum expansion and contraction of the rail by the extreme changes of temperature without shearing the bolts. A simple and very effective contrivance known as the Verona Nut Lock, consisting of a steel ring, cut through slantwise so as to leave sharp knife edges at the cut ends, coiled and tempered to a spring of about 1,500 pounds elastic resisting capacity, is usually interposed as a washer between the angle bar and the nut of the bolt which fastens the angle bar to the rail. This washer has obtained a very extensive application throughout the country, and although not an absolutely perfect lock against turning and liable to loose its elasticity in course of time, it appears to answer the purpose as well as any other devise heretofore employed while its cheapness and simplicity of application, present advantages which no other appliances known to me appear to possess.

The complete splice as above described is shown on the sketch, Figs. 3 and 4; this is the splice used as a standard on the lines of the Pennsylvania Railroad System, and is the one to which my observations, of which I will speak directly, have been chiefly confined. As applied on the lines above named, it is a so-called "suspended joint," the rail ends meeting midway between two cross ties, and the ends of the angle bars resting upon the two joint ties, forming to all intents and purposes a compound beam resting upon the two end supports with the two adjoining rail ends sandwiched between the bars, and the whole united together by the bolts.

Now how could such a beam be affected by a load?

To determine the effect of an external force upon the different component parts of a composite body is attended with but little difficulty, if the parts are uniform, equally affected and homogeneous in their character, but the difficulty increases as the relations and connections of the component parts of the body become more intricate among themselves and more at variance with each other. In order to determine the effect of a given load upon a compound beam composed of the two ends of adjoining T rails, spliced and bolted together by two splice bars in the manner above described, it would seem rational to investigate first the effect of the load upon the rail ends, independent of the splice bars; then ascertain the effect of the load upon the splice bars, independent of the rail ends, and then determine whether the one or the other of the members alone is affected by the load, or whether both are affected and in what ratio to each other, or whether the combination of the members affects the resisting capacity of either, and if so, to what extent.

Fig. 2

Fig. 1

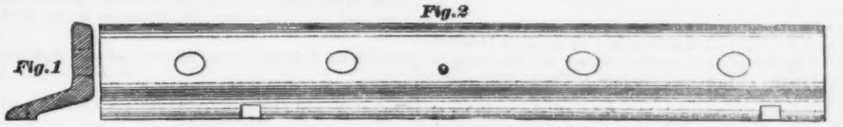
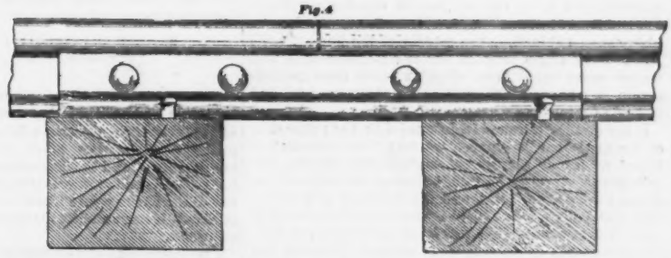


Fig. 3

Fig. 4



Taking for an illustration the section of an ordinary T rail of the Pennsylvania Railroad Standard pattern, weighing 69 pounds per yard, we find that its sectional area = 6.81 square inches, that its centre of gravity lies almost exactly in the middle or its height and that its moment of interia is = is 17.43. Spacing the cross ties so as to distribute 16 ties to a 30 foot rail, they will then be 22½ inches apart between centres, and allowing 8 inches top face for each tie, the clean span of the unsupported rail equals 14½ inches, and the projecting part from edge of support to the rail end at a splice is 7¼ inches; if the driving wheel of one of the large passenger engines with its weight of 20,000 pounds rests at the tip of the rail end unsupported by the splice bars, and the other end is considered fixed, or what is very nearly the same thing, continuous over the end support, the effect of the load would be to depress the tip end of the rail with a tendency to rupture the rail at the point of support over the edge of the cross tie by tearing apart the fibres of the top flange, and crushing the fibres of the bottom flange of the rail; in other words, the maximum bending moment under the conditions stated would occur at the point of support and would be equal to the load multiplied by the distance between the load and supporting point; $M = Wl = (20{,}000 \times 7\frac{1}{4}) = 145{,}000$ pounds, and the stress in extreme fibres of the rail section would be equal to $S = \frac{M}{\frac{I}{e}}$; in which S = fibre strain per square inch, I = moment of inertia, e = distance of neutral axis from extreme fibres, making $S = 18{,}300$ pounds. The actual tranverse strength of the projecting rail, assuming maximum fibre strain at crippling point to be 45,000 pounds = 49,175 pounds.

The deflection due to this load would be $\frac{W l^3}{3 E I}$ = 0.0054 inches, in which formula, E = modulus of elasticity of mild steel, assumed at 27,000,000, being the average result of fifteen experiments made recently by the Pencoyd Iron Company on mild steel deck beams and I beams. (See James Christie's paper on strength and elasticity of structural steel in August Number of Transactions American Society Civil Engineers.)

If we consider the engine wheels with its weight of 20,000 pounds, so placed as to rest directly over the splice, and one-half of its weight carried by the tip of one rail and the other half by the tip of the other rail, then the maximum bending moment would be one-half the amount ascertained above, or 72,500 pounds; the stress on the extreme fibres would be 9,150 pounds and the corresponding deflection at the tip end of each rail would be 0.0027 inches.

You will observe that these figures are derived from the theoretical effects of purely static, quiescent loads, and would not, of course, compare at all, with the practical effects of moving loads with their accompanying impact, but for the present purpose, of investigating the comparative transverse strength of the component parts of the rail splice, the conditions above assumed will answer. So much then for the rail part of the joint.

To ascertain next the effect of the wheel load upon the two angle bars, considering them firmly united to each other, and doing equal duty, the wheel resting in the middle of the bars, and the bars standing in their normal position as if spliced but disconnected from the rail, is somewhat more complicated than the determination of the resisting capacities of the rail section.

A mere glance at the shape of the angle bars and their position in the completed joint will suffice to show, that the effective capacity of the bars to resist a vertical load applied in the middle of their length cannot be determined from the elements, which enter into similar solutions in bodies of symmetrical sections, with their centres of gravity, neutral axis and centres of gyration on lines normal and at right angles to the direction of the load. Neither can it be assumed that all parts of the angle bar section would be effective under the usual methods for determining the strength of symmetrical bodies. Take for instance a case slightly exaggerated, but still illustrating the point in question; if the two legs of the angle bars were of equal length and thickness and inclined to each other exactly at right angles; one leg standing perpendicular and the other resting with its entire surface upon a horizontal support, the center of gravity of the bar would in such a case be outside of its cross section, in the angle between the two legs.

Now if a load were placed on top of the vertical leg of the angle, its effect upon the extreme fibres of both legs certainly would not be equal, although the fibres are equi-distant from the geometrical neutral axis; indeed it is very evident that the horizontal leg does not carry any considerable part of the load and that the part of its section outside of the prolongation of the vertical leg is not effected to any great extent, if at all, although the surplus metal contained in the horizontal leg may increase the tensile strength of the lower part of the section, as against the compressive strength of its upper part, where no corresponding surplus metal exists. In other words, the *geometrical* neutral axis of of the bar section is not the proper datum line from which to deduce its strength; but that another line, which may be called the *static* neutral axis, is much more nearly the datum line for the development of the moments and stresses due to vertical loads.

But referring again to the sketch it will be noticed that owing to the peculiar attachment of the bars to the rail, the transmission of the load through the rail head by way of the inclined contact line under the rail head, and the retransmission from the angle bar to the top of the inclined rail base, the direction of the thrust is somewhat problematical; it certainly is not vertical, but its vertical origin is decomposed into two oblique forces, the direction and magnitude of which I have endeavored to locate by the following methods:

The location of the neutral axis was ascertained by balancing a brass templet of the angle bar section over the edge of a knife blade, taking care to maintain the knife edge parallel to the bottom line of the templet. The moment of inertia about this horizontal axis was then calculated in the usual way, and from it the radius of gyration.

To locate the centres of inertia upon the platted cross section of the bar, the respective centers of gravity of the portions above and below the neutral axis were determined, and a line drawn through these centres of gravity.

These centres of inertia were taken on this line at a perpendicular distance from the neutral axis equal to

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the radius of gyration. This result is shown in figure 5.

The two centres of inertia are not in the same vertical line, and the line joining them is *inclined* to the vertical, and therefore also inclined to the line of action of he load.

The resistances of the upper and lower segments, with reference to a vertical load and horizontal axis are not in the same plane, and if the bar were not supported laterally, it would rotate upon its base. But if supported laterally the resultant force *must* act along the inclined direction, and with two bars bolted upon the sides of the rail, we obtain the conditions shown by Figure 6.

The force acting upon each angle bar will be the component of the vertical load, in the direction of the inclined line of resistance; and the resistance of the bar will not be represented by its moment of inertia about a horizontal axis, but by its moment about an axis at right angles to the inclined line and through the centre of gravity of the section. The value of *this* moment has therefore been calculated and is the one which has been used for calculating the strength and the deflection of the angle bar. The angle which this oblique line of resistance makes with the vertical and also its secant are shown on the figure marked 5.

The sectional area of one of the angle bars for a 69 pound rail is 2.671 square inches, its moment of inertia = 3.147, its radius of gyration is 1.086, and the angle between the vertical and the line of thrust as developed above is 35 degrees.

Considering the angle bars to be of iron, with an allowable fibre strain of 25,000 pounds per square inch, the calculated transverse strength of the two bars, disconnected from the rail, would equal a vertically applied load of 17,300 pounds, and the flexure under the above assumed load, in the middle of the bars, = 0.0074 inch. Steel angle bars of the same dimensions and under equal conditions, allowing 45,000 fibre pounds strain per square inch, will, carry 28,850 pounds and deflect 0.007 inches.

If the method pursued in determining the properties of the angle bar is correct, we may then presume to know, as far as theoretical calculations permit, the transverse strength and deflection of the rail section alone, loaded at the joint, and the strength and deflection of the angle bars loaded in the middle independent of the rail; the next step will be to ascertain the combined strength of the two, when properly attached and united to each other, for in that manner the load will be applied in practice.

As shown above, the actual transverse strength of the projecting rail end is 49,175 pounds; its fibre strain, due to a wheel load of 20,000 pounds, is 18,300 pounds, and its end deflection is 0.0054 inch; the actual transverse strength of the angle bars is 17,300 pounds with a fibre strain, due to the wheel load, of 25,200 pounds for the top flange, and 27,800 pounds for the bottom flange, and a deflection, under equal load, of 0.0074 inch. The work done by that load, acting upon the completed splice, consists of bending two projecting rail ends and the pair of angle bars through a deflection distance, which, from the nature of the fastenings, must be common to all the members in the combination; and this equality of deflection affords the means of determining what proportion of the load is borne by the rail and by the splice bars respectively.

The general formula for deflections are:

For projecting beam loaded at the end—

$$d = \frac{W l^3}{3 E I} \qquad (a)$$

For beam on two supports loaded at the center—

$$d = \frac{W l^3}{48 E I} \qquad (b)$$

Let W = total wheel load.

Let w = that part of W expended in bending each projecting rail end,

Let w' = that part of W expended in bending the pair of angle bars.

Let I = moment of inertia of the rail section.

Let I' = moment of inertia of the two angle bars.

Let L = clear span between joint ties.

Let $\frac{L}{2} = l$ for rail ends.

Let l' clear span between intermediate ties.

By substituting these values in equation (a) and (b) we have:

For each rail end -

$$d = \frac{w \left(\frac{L}{2}\right)^3}{3 E I} = \frac{w L^3}{24 E I} \qquad (1)$$

And for a pair of angle bars—

$$d = \frac{w' L'^3}{48 E I'} \qquad (2)$$

The deflections being alike for both we may write—

$$\frac{w L^3}{24 E I} = \frac{w' L'^3}{48 E I'} \qquad (3)$$

By cancellation this becomes—

$$\frac{w}{I} = \frac{w'}{2 I'}$$

Or

$$\frac{2 w}{I} = \frac{w'}{I'}$$

Which may be written $2w : w' = I : I'$ (4)

From which also $2w : 2w + w' = I : I + I'$

But $2w + w' = W$

and by substituting $2w : W = I : I + I'$

from which

$$w = \frac{W}{2} \frac{I}{I + I'} \qquad (5)$$

Recurring to (4) and taking the sum of the terms in the reverse order we have—

$$2w + w' : w' = I + I' : I' \text{ or } W : w' = I + I' : I'.$$

from which

$$w' = W \frac{I'}{I + I'} \qquad (6)$$

These two equations, (5) and (6), determine the proportions in which the load is distributed to the several members composing the joint. In other words, the total load W so applied as to rest equally upon the two rail ends, and transmitting its force through the rail ends, upon the angle bars, in such manner as to produce equal deflections in the rails and angle bars, is decomposed into the forces w and w', the former acting through the rails and the latter through the angle bars.

Now if figures tell the truth, the stress on the flange fibres of the angle bars, produced by that part of the total load W which causes the deflection in the bars

equal to the deflection of the rail, $= w' = \frac{W I'}{I + I'}$ and $S = \frac{W L l \text{ Sec. } a}{4 (I + I')} = \frac{20000 \times 14.5 \times 2.2 \times 1.22}{4 (17.43 + 6.29)} = 8,190$ lbs. ....(7)

and the stress on the flange fibres of the projecting rail end, produced by that part of the load W which causes a deflection in the rail ends equal to that of the angle bars,

$= w' = \frac{W}{2} + \frac{I}{I + I'}$, and $S = \frac{4 (I + I')}{W L l} = 6.724$ lbs. .....(8)

These figures would bring the fibre strains in angle bars and rails within the limits usually allowed for safety, even if we allow an addition of 50 per cent. to the load for impact, but when the uncertain effects of lateral shocks and the centrifugal force of rapidly moving trains is added, the exterior angle bars on the outer rail of the curve would likely be found deficient in safe strength, if not actually strained beyond the limits of elasticity.

The fibre strain of a portion of rail resting upon two intermediate cross-ties, loaded in the middle, $= S = \frac{1}{4} \frac{W L}{\frac{I}{e}}$, or 9,150 pounds, and, if the rail is considered fixed at the supports, which, on account of its continuity, is more nearly its actual condition, the fibre stress is only 4,575 pounds, showing that the body of the rail is nearly twice as strong as the angle bars and fully 50 per cent. stronger than the projecting rail ends at the joints.

Referring again to formulæ 7 and 8, we notice that the fibre stress in the projecting rail ends, due to that part of the load W which produces the equal deflections in rail ends and angle bars, $S = \frac{W L}{4 (I + I')}$, and that the fibre stress in the angles due to that part of the load W, producing its effect upon the splice bars, $S' = \frac{W L e' \text{ sec. } a}{4 (I + I')}$.

Comparing these equations, we see that if the rails and splices were of equal metal, they would be of equal strength if $e = e' \text{ sec. } a$.

But the allowed maximum fibre strain S in steel is 45,000 pounds, while that for iron S' is only 25,000 pounds per square inch, both figures applying to the limit at which crippling takes place.

From this $S' = \frac{5}{9} S$.

For rail on intermediate ties $S = \frac{W l e}{4 I}$,

$$\frac{5}{9} S = \frac{5}{9} \frac{W l e}{4 I} = \frac{W L e' \text{ sec. } a}{4 (I + I')},$$

or

$$\frac{5 l e}{9 I} = \frac{L e' \text{ sec. } a}{(I + I')}$$

$$L = \frac{5 l (I + I') e}{9 e' \text{ sec. } a \, I}$$

For 67 pounds rail, this is equal to $L = l + 0.61$; or, in other words, if intermediate ties are spaced 14½ inches apart, joint ties, in order to make the joints of equal strength with the body of the rail, should be spaced only 8.84 inches apart.

This corresponds exactly with the experiments made by Baron von Weber, Minister of Public Works of Prussia, in which he measured, by registering scales placed under the rails, the different deflections, caused by the passing loads upon rails between joint ties and between intermediate ties, and from which observations he established the general rule, that with the ordinary angle bar splices joint ties should be placed 0.6 the distance of intermediate ties. [See his report in London *Engineering*, vol. X, page 294.]

It is not presumed that the foregoing figures are intended to show the actual strength of the splice joints, or even give an approximate approach thereto, but they cannot fail to demonstrate the relative weakness of the joints as compared with the body of the rail. Add to this inherent weakness the many causes tending to aggravate the case, such as the imperfections in the track, even under the most careful supervision, flat wheels, worn ties, rough wheel flanges, loose bolts and rough surfaces of contact of the parts composing the rail joints, and you may well say, "no wonder that they break." Of course, these aggravating causes apply, at least to a certain extent, to the other portions of the track, but they exert themselves more effectively in the weaker spots, and the fact still remains that the joint is the weak spot in the track, and, since the greatest strength of any structure is only that of its weakest part, it seems strange that so little has been done by the profession to investigate this subject and improve the existing defects; and when, in addition to what I have said to you on the theoretical weakness of these joints, I tell you that I have found 1,130 broken angle bars on a single division of six miles of track, you will naturally be surprised; and I confess that I was quite startled by the discovery.

On six miles of track, counting the rails to be of 30 feet length, there are 2,112 joints, or 4,224 angle bars, of which 27 per cent. were found broken, but, strange to say, every one was broken on the top, in the middle of the joint, between the two interior bolt holes, the fracture extending from the outer edge downwards in lengths varying from ¼ inch to the total width of the vertical leg of the angle bar, but in not a single case did the fracture extend into the bottom flange or horizontal leg of the angle bar, and the rupture was in every case a clear tear, evidently caused by extension of the upper fibres of the top flange.

You will see, therefore, that these fixtures do not break according to the rules of the books. They defy your statical moment and sneer at your modulous of resistance. They break most numerously where entirely new, just after being laid, notwithstanding the most perfect support and most careful adjustment. They break everywhere, although they do it most persistently on gravel ballast, but, in the absence of any ballast, they break as well; indeed, they seem to have a preference for the smooth and perfectly built floors of iron bridges and viaducts.

It is undoubtedly true that a large share of this destruction of joints is due to the defective metal in the bars. I never had any analysis made of the material, and I cannot definitely say to what extent furnace cinder preponderates in the composition. Some iron manufacturers (present company, of course, excepted) do sell some very inferior metal to railroad companies occasionally, just for the purpose of showing how easy it is for them to deceive the young graduate from the Polytechnic Institute, who is learning the practical part of the profession at the expense of the railroad company, while serving with the title of "inspector" at a rolling mill.

These failures, however, did not occur with angle bars of the sections shown in the preceding figures, the dimensions of which have been used in the foregoing calculations; they occurred with bars, a section of which is shown in Fig. 7. The present standard section is slightly increased, and it is proper to state that thus far no failures have been reported of the new bars, of which a small number have been recently laid.

The original advocates of the so-called suspended rail joint never anticipated such results, nor did its opponents ever point them out. The effect is due to causes not looked for by either side. What, then, is causing the mischief, and what is its remedy?

When we find a piece of iron bent downwards at the ends, with the upper fibres pulled apart in the middle and the lower fibres crushed, we know that either one or the other of the ends was bent downwards over a middle support, while the other end was being held in position, or that both ends were bent down together. Again, we know that the construction of a projecting beam of uniform strength throughout its length must be such that each cross section, no matter where taken, is of such area as to satisfy the bending moment produced by the load. This would imply a structure similar to the gradual re-enforcements from projecting end to supported part, in a spring with its successive layers of leaves, or the increasing diameters of the tubes of a sliding telescope. If any section be of less area than that required to satisfy the bending moment of the load, rupture would take place at that point.

Now, it must be admitted that, although the action of the forces affecting a rail joint is different from those assumed in the foregoing calculations, there is still ample proof that the joint is really the weak spot in the track. This weakness naturally admits of a greater movement and vibration under passing loads at the joint and its adjacent supports than at any intermediate points. Standing alongside of a railroad track when a train passes over it, this fact becomes at once apparent to the observer. It is very noticeable during a rain, on a line ballasted with fine gravel or sand when the disturbance of the joint ties will cause water to collect under them during the upward movement, which water is again forced out by the downward movement, cutting well-defined gutters from the ends of the joint ties down the ballast slopes, while no such effect is noticeable at the intermediate ties. I have even observed similar evidence on the sand-ballasted railroad

of the western plains, during high winds, which blow away the ballast from the ends of the joint ties, where it is agitated by their movement under the passage of trains, while no such effect is produced elsewhere along the track.

Unless these joint ties receive extraordinary special attention, on the part of the trackmen, their neglected condition will inevitably cause the troubles above related. Indeed, I doubt very much whether any amount of care would prevent the natural consequences of a defect inherent in the present arrangement.

Suppose the ballast under the joint tie *A*, Fig. 8, to be washed out to the extent indicated while the joint tie *C* is undermined to a less degree or not at all. When the heavy driving wheel of an engine strikes the tie *A*, the deflection produced by the load would cause bending or probably rupture at *C*, if the beam (rail and splice combined) were of uniform strength throughout; but the rail being severed at *B*, the strength of that part of the beam between *A* and *B* consists of the angle bars alone, and if the capacity of the angle bars to resist the moment of the load and its leverage *A—B* is less than the united capacity of the rail and angle bars to resist the moment of the load and its leverage *A—C*, then rupture must take place at *B*. The fibre strain in the angle bars at *B* is found by calculation to be almost double that of the fibre strain in rail and angles combined at *C*, and rupture at *B* would therefore be inevitable under the circumstances, if the load at *A* and its impact are sufficient to produce it anywhere.

There is upon any railroad track, irrespective of its support, and noticeable even upon the most rigidly ballasted road-bed, a wavelike motion, preceding every approaching train, conforming, in an irregular manner perhaps, to the rise and deflection under a passing load of a continuous beam resting upon several supports. This wave would undoubtedly terminate in an upward movement at any joint between two supports, where the continuity of the beam ceases; and some theorists have attributed the ruptures in the upper flanges of the angle bars to this cause, but the undulations caused by this wavelike movement are too insignificant to produce such an effect, if the supports all maintain their fixed positions in the plane. Until convinced by better proof, I am inclined to adhere to my opinion that the rupture of the angle bars is purely tensional, caused by the two rail ends acting successively as cantilevers on each half of the length of the angle bars, with a maximum strain at the middle of the bars.

This action is, moreover, aggravated whenever, by wear or slackening of the nuts or bolts, all surfaces of the joint connection are no longer in perfect parallelism; the movement tending to break the bars is twice repeated by the passage of every wheel, first, as it approaches the leading tie, causing that to be depressed (even in the best stone ballast) for a certain distance, while the receiving tie, with its rail end and its half of the angle bar, remains in another plane, its normal position; evidently, being bolted together, the one end loaded, the other free, there must be a bending moment on the bars which connect them equal to the difference in actual level, however small, of the leading and receiving ties into the load, and aggravated by the momentum and many incidental causes, the next instant this movement is reversed; now the receiving tie has the load and the first leading tie, with its rail end, is free, its own elasticity and that of the rail tending to raise it to its former normal position. In both movements the bars receive such a strain as to produce, after a number of repetitions, the rupture above described.

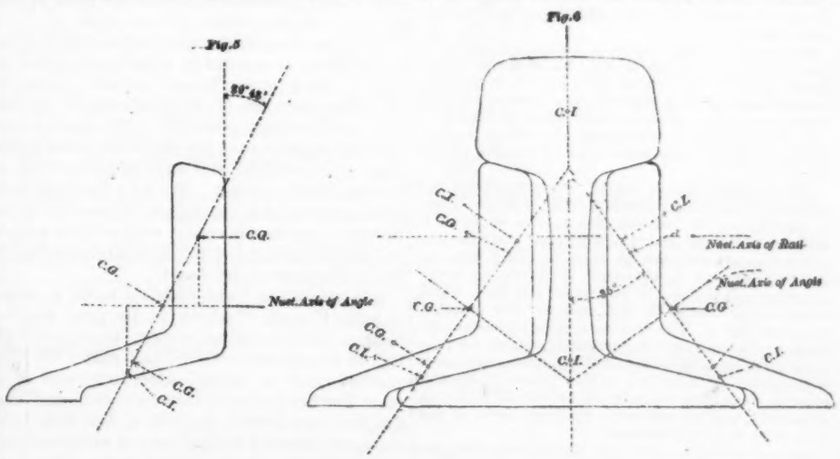
This solution seems sufficiently satisfactorily to me as far as the breakages on ballasted track are concerned. As to that part of the conundrum relating to the breakages on perfectly floored bridges and viaducts, I am constrained to follow the well-known example of that much traduced animal that tried to join its mate on the opposite shore without crossing the stream—I give it up.

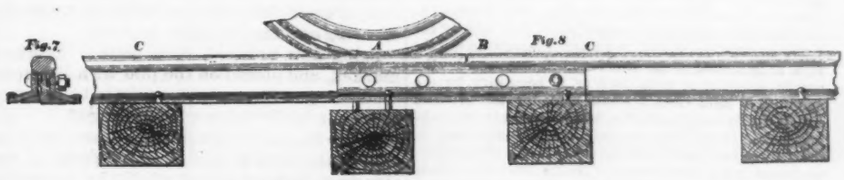
For the purpose of comparing theory with practice, I give you below the results of seven tests made by Mr. T. Rodd, under the supervision of Mr. Onward Bates, both members of this Society, of the transverse strength of several types of rail joints in use in 1876. These tests were made at the Keystone Bridge Works. Steel rail ends of 60 pound weight per yard, and of the standard section used by the Pennsylvania Company at that time, were spliced and bolted together in the usual manner, successively, with straight splices, with straight splice on one side and angle bar on the other; with double angle bars of Pennsylvania railroad pattern; with double angle bars of Pennsylvania Company pattern; with two straight Samson bars; with straight Samson bar on one side and angle Samson bar on the other, and with double Samson bars. A test was also made of the transverse strength of a solid piece of 60 pound steel rail twenty-four inches long. The piston pressure was applied in the middle of the lengths of the spliced end of the rail section with the following results. The series embraced eight experiments, as follows:

No.	Description.	Length.	Weight
1	P. R. R. standard 2 straight bars	24 inches	18 lbs.
2	" " 1 " and 1 angle	24 "	27 "
3	P. R. R. standard 2 angles	24 "	35 "
4	Penna. Co. standard 2 angles	24 "	29¾ "
5	Samson joint 2 straight bars	24 "	20 "
6	" " 1 " and 1 angle	24 "	25½ "
7	" " 2 angles	24 "	26½ "
8	Steel rail 60 lbs. per yard	.....	.....

TESTS FOR TRANSVERSE STRENGTH OF RAIL JOINTS.

	No	Deflection under Successive Loads. 10,000 Deflection.	10,000 Permanent set.	15,000 Deflection.	15,000 Permanent set.	20,000 Deflection.	20,000 Permanent set.	25,000 Deflection.	25,000 Permanent set.	30,000 Deflection.	30,000 Permanent set.	Ultimate Load.	Ultimate Deflection.	Remarks.
Fish	1	1/16	0	1/16	0	3/32	0	1/8	0	5/32	1/4"	50,960	3"	Broke 1 bar.
Fish and angle	2	3/32	0	1/8	0	1/8	+	3/16	1/32	1/8	1/16	60,060	2 1/16"	" 2 bolts.
Penna. R. R. angle	3	0	0	1/16	0	1/16	0	3/32	1/64	1/16	1/32	79,300	.....	" " "
Penna. Co. angle	4	1/16	0	3/32	0	1/16	0	1/16+	0	3/32	1/32	83,720	3"	" " "
Samson fish	5	3/32	0	1/16	+	3/32	1/32	3/32	1/32	.....	.....	76,700	8 1/16"	" " "
Samson fish and angle	6	3/32	0	1/16	3/32	3/32	1/32+	3/32	3/32	.....	.....	74,700	3 1/16"	2 1/16" lat. defl. of angle
Double Samson angle	7	1/16	0	1/16	1/64	3/32	1/32	3/32—	1/16	1/8	1/16	78,000	2 1/16"	Broke 1 angle, some lat. defl. of sound angle.





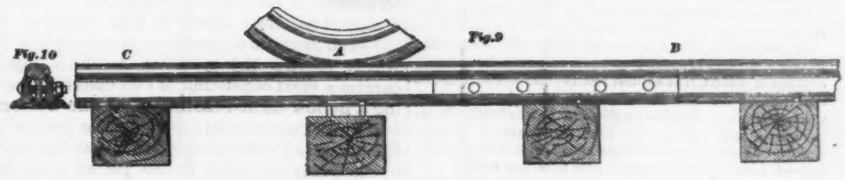
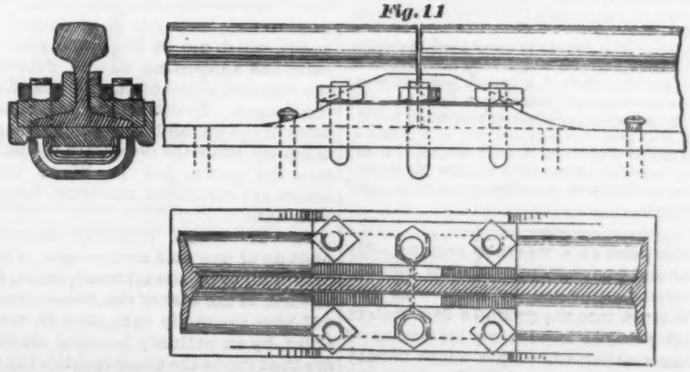


Fig. 11



The tests were made on bearings twenty inches apart, with results as follows: (See large Table.)

In test No. 8 the solid rail, 60 pounds P. R. R. standard, showed first permanent set of 1-64 inch, at 97,500 pounds load, and at 182,000 it failed by splitting under the head

The Samson bar is a modification of the fish bar and angle bar, consisting in a reduction of the sectional area near the ends of the bars to save metal and a very slight increase over the sectional areas of the fish and angle bars in the middle.

The tests show that while the straight Samson bar is somewhat stronger than the straight fish bar, the Sam-

son angle bar presents no advantages over the regular standard angle bars. The tests of the joints composed of one straight bar and one angle bar give, as may be expected, rather unsatisfactory results.

The strength of the solid rail, as developed by the test, is more than double the strength of the angle bar joint, which proves the correctness of the theoretical calculations.

Upon several lines of railway, angle bars are used in the manner first above described, but the joint is supported by a cross-tie directly under the rail ends in the middle of the splice bars, as shown on Fig. 9. Such a joint would seem exposed to danger from two sources; in case the first tie from the joint is low, the load would still tend to rupture the angle bar on the top flange by tension, the load at *a* acting with a leverage *a-b*, the edge of the joint tie, *b* being the fulcrum, a slight upward movement must occur at the rail ends every time a wheel passes from *c* to *b* over the depressed tie *a*, tending to rupture the angle bars at *b*; and, in case the joint tie itself is low, the load at *b* would tend to compress the top flanges of the bars with a force increased by the lengthened span between supports.

Angle bars have also been introduced of sufficient length to extend over three ties, the rail ends meeting over the middle tie; this evidently stiffens the unsupported portions of the rail between the middle tie and two adjacent ties and overcomes the tendency to rupture of the upper bar flange at the joint but it does not relieve the two other troubles mentioned in the last case, and I doubt whether the additional cost of the joint is compensated by the advantages it may possibly afford.

Still another form of splice is coming into use, a section of which is shown in Fig. 10. If the breakages heretofore described would have been avoided by a larger top flange area, then this new section of angle seems to afford a remedy; to what extent its sharp reentering angles may complicate the rolling process, especially in steel bars, some practical member may be able to say.

The so-called "Fisher Joint" is recommended and endorsed by engineers who have tried it in the track; it consists of a "U"-shaped trough, of a width to fit the base of the rail, and of a length of about twenty-one inches, the ends resting upon two joint ties, the rail being secured by U-shaped bolts, passing under the splice and fastened by nuts to the rail base, which is checked or slotted for that purpose; the device is shown on Fig. 11. The trough certainly prevents deflection of the rail ends, and its sides confine the rails against lateral displacement, but its introduction meets with opposition on account of the radical changes it involves, embracing not only the slotting and punching of the rails, but the necessary checking down of the joint ties to receive the plates.

The best joint is the one that accomplishes the purpose fully at the least cost. The economical limit for a practical and safe joint seems to have been reached in the standard angle bar above described, and if the breakage can be avoided by a slight increase in the section, as indicated in the standards of 1884, and by the careful selection of good iron or, if necessary, by the adoption of mild steel, I would consider the problem satisfactorily solved as far as actual danger from weakness of the joints is concerned. The increased wear of the connecting parts, and the consequent irregularity produced in the movement of trains over the joints, will not be overcome until a joint is invented as perfect as the unbroken rail, which amounts to an impossibility.

In conclusion, allow me to apologize for presenting to you a subject of so little general interest, the consideration of which, if it should receive any at all, must be confined to the few unfortunates, who share my own unenviable lot. But the profession is gradually disintegrating into specialties, and the pursuit of one branch of knowledge is becoming enough for one man; indeed, I have found it sometimes to be too much.

The universal genius is becoming scarce in this world and we must content ourselves to give and receive such contributions as our limited individual stock in trade will afford.

Perhaps, after all, some of you never knew that splice bars would break, and you might have been killed on a railroad from the effects of a broken joint and never have known the cause. Of course, to a dead man, this would not be a matter of much consequence, but the knowledge that your untimely end was due to distortion of the radius of gyration in a rail section, or to the buckled-up moment of inertia in a splice bar, might, perhaps, be a source of consolation to your grief stricken widow.

THE TELEPHONE AS A WEATHER PROPHET.—By observing and comparing the sounds emitted by a telephone connected by leads with two iron bars, stuck into the ground a few meters apart, it is possible to have an indication of the coming weather, sometimes ten or twenty hours in advance—so says *La Frankein*. In case of a thunderstorm, especially a noise like that of shrivelling leaves increases until a flash of lightning occurs, when it resembles that of rain or hail falling on glass.

THE FORTH BRIDGE.

On Manipulating the Material, and Building, and Drilling the Great Tubes of the Forth Bridge.*

BY ANDREW S. BIGGART.

(*Concluded from page 132.*)

The plates after having been brought to their true form, as already described, are passed on to a large planing machine, as shown (see Fig. 12,) to be there planed on both sides.

This is an ordinary planer, having the table driven by a 6 inches screw, but supplied with double cheeks, between which, on each side, is fixed the special tool boxes A A. The plate being operated upon is placed on cast-iron curved blocks B, and held down to the table by means of bolts and draw washers, arranged so that they can be either quickly tightened up or loosened at will. Both tools cut simultaneously, and as the plate is being travelled backwards, as well as forwards, they are fed into their work, and reversed by hand.

When the sides have been planed, the plates are placed in another machine (see Figs. 13 and 17), to be there planed on both ends.

They are here supported from and held down to the table at one end in a manner similar to that adopted for the former machine, while at the other they are fixed by means of screws through the beam overhead. Wedges are also driven in tightly, at the sides, to prevent the plate being shifted sideways by the action of the tool while cutting. The tool box and tool T are carried in a pendulum P, receiving its motion from the travelling saddle S, by means of the connecting rod R. Here also the tool is fed, and reversed, by hand.

The pendulum P and plates Q have a series of holes H, each of which in its turn will be made a new swinging center, to enable the tool to sweep the ends of the plates for the various sizes of tubes. After one end of a plate has been planed, it is reversed, and the finished end butted against a cast-iron face plate, set parallel to the plane of motion of the cutting edge of the tool, thus making the two ends of each plate truly parallel, and thereby securing accuracy at the tube joints.

Being now finished, each plate is weighed, marked, and placed on the pile with the nearest corresponding weight, ready to be removed and built on the tubes when required.

In the shops the handling of these plates, as well as the rest of the heavier parts of the structure, is done almost wholly by hydraulic cranes of the style shown in Figs. 5 and 6. In the ground there is placed a cast-iron box B, which carries the cylinder A. This again carries a mast consisting of two channels, having a hollow turned casting H at the bottom, and a solid one S at the top. In the center of the latter is fixed a pin, which allows the mast to turn, carrying with it the jib, as in an ordinary crane, but with this great difference, that it can make a complete circle. The jib is fixed to the piston rod P by means of cross-heads, which are at the same time made to carry the supporting wheels, running inside the channels of the mast, and bearing against the flanges. By this means the bending moment of the jib, and the weight thereon, are taken up, while the downward thrust is passed into the piston rod P. When loaded, the cranes are capable of handling fully two tons with ease.

The H beams, formerly mentioned, are built up of tee and angle bars. These have first of all to be straightened, which is accomplished, in the case of the former, by means of a 15-inch hydraulic ram, and in that of the latter, by an ordinary bending machine. All are then cut to the exact length of 32 feet, by a cold steel saw moving with a velocity at the periphery of about 70 feet per minute.

*Paper read before the Institution of Engineers and Shipbuilders in Scotland.

They are now ready to be built into cast-iron blocks on the drilling tables, and in building it is carefully attended to, that there is a distance of 16 inches between the different joints of the angles, while those of the tees are placed midway between those of the angles.

To secure good butting, the end of each new beam about to be built is placed hard against the one already set up, and to which it will be joined when placed in the tube; that is the end of the new one is brought hard up against that of the old one, tee to tee, and angle to angle.

Every thing being now in order, drilling, through angles and tees at one and same time, proceeds, by means of radial drills of the style shown (see Figs. 18). When this part is finished, the beams are marked and laid aside till required to be placed in position, on the mandrels, where, as is evident, the joints will meet as fitted in the shop. Thus this section proceeds, beam following beam till the total length required is completed.

It may be mentioned that, as regards the arrangement of the tables, they are placed on each side of the line of radials, which allow building up to go on at the one side while drilling is being proceeded with at the other.

To insure accuracy in the form of the tubes, and also correctness in workmanship, the stiffening circular girders (see Fig. 1,) are built within a wrought-iron ring the inside diameter of which is 12 feet, this being the mean size of the tubes at present under consideration. Within this ring, and at equal distances apart, are placed ten castings, each of which occupies the same relative position to the different parts of the girder as the longitudinal beams in the completed tube. These are also of a form suitable for carrying the various parts of the girders while being drilled. When the girder has been built in this iron frame, all the holes are marked off to template, and afterwards drilled by a radial drill, the centre of the column of which coincides with that of the girder. Although some of the girders vary slightly in diameter at some parts according to whether they are off or on joint-cover this is easily overcome by fixing temporary packing strips against the ring to suit the new dimension to which they are of necessity built. After drilling, the separate parts are all marked, removed, and bolted together, awaiting erection on the mandrel.

The angle-iron rings for these girders are curved on a large cast-iron segmental block. A pin is fixed into the centre of this segment, round which a large wrought-iron arm carrying a curving wheel is moved. This wheel is of a form suitable to bear against the outside or inside of the bar as may be required. When the angle is heated, one of the ends is grabbed to the segment behind the wheel and the arm is now gradually moved round. The wheel bearing hard against the angle brings it close to the face of the segment, and it thus receives the proper curve. To assist the curving, a crowbar has to be used in front of the curving wheel to bend up the angle, while behind the wheel additional grabs keep it close to the segment. After the full bar has been curved in this manner, the grabs are removed and the wheel run backwards and forwards several times, and then it is ready to be removed, and with a little trimming up, is fit to be used in any of the girders.

Having now considered the principal parts which compose the tubes, the building and drilling of these will naturally follow. This work is done out in the open, on what is called the drill roads, (See Fig. 16). These are laid down to suit the drilling machines, and at such a distance and with such a length as to allow the bracing girders and connections thereto, to be placed in position, as the work stands on the ground, prior to the final erection.

THE FORTH BRIDGE; DRILLING MACHINE FOR TUBES.

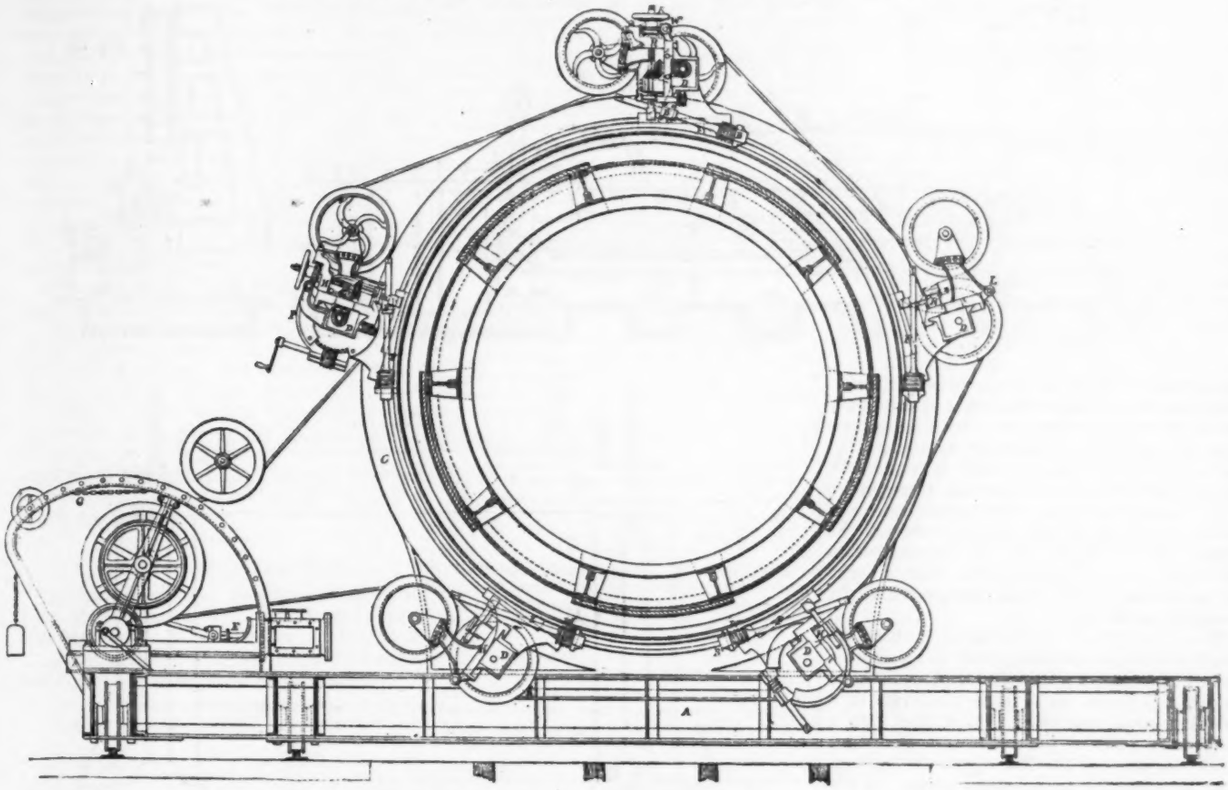
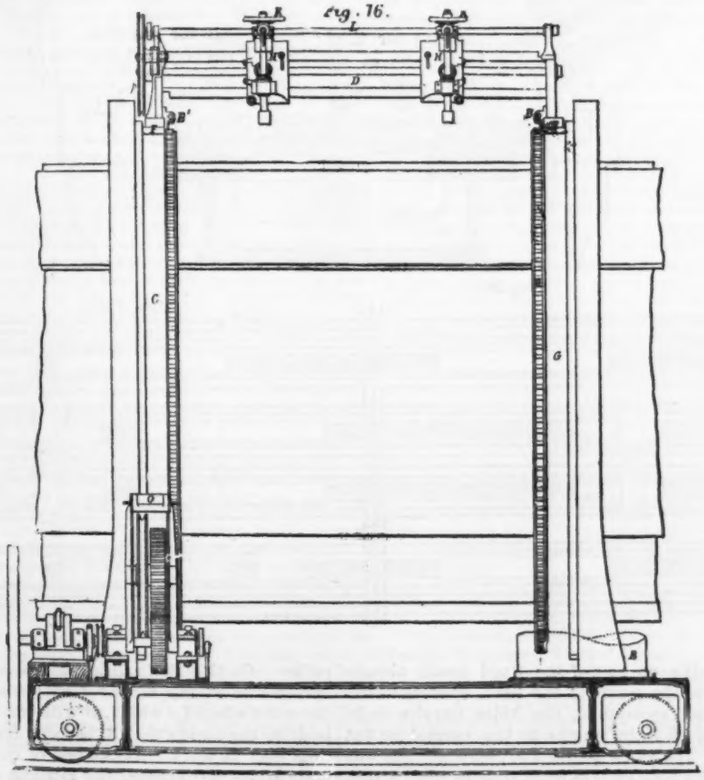


Fig. 16.



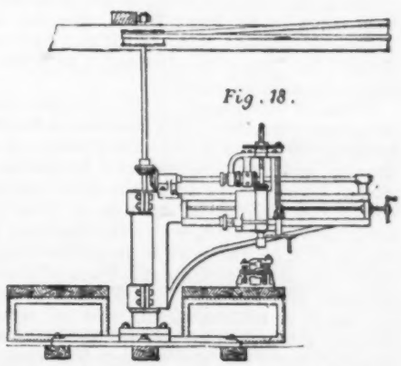


Fig. 18.

The roads are so arranged as to be all equally suitable of access for the steam travelling cranes used in carrying the material to position, and in building the tubes. This is accomplished by means of traversers, of which there are three, one in the centre and one at each end of the drill roads, those at the ends running on rails, at right angles, and close to the main roads, but fully 12 inches lower, while the centre one is run on cross rails, on the same level as the main roads. If it is necessary to change the position of a crane, it is run on to the traverser, and is carried to the desired point, and there run off. In this way the whole of the ground is commanded by the cranes. It has already been said that the material for the tubes is placed in position by means of these cranes, the work of building, as required in any of them, will now be described.

Fig. 4, shows the style of building. First of all there is the mandrel M, 45 feet long by 5 feet diameter raised on iron trestles T, to a height, at the centre, of 10 feet from the ground. This corresponds with, the centre of the outer rings of the drilling machines.

The great length of mandrel required is to allow of its being carried up at the ends when the H beams and plates are built in position. On this mandrel there are now secured, but in halves, temporary iron rings R, at the horizontal distance from each other of feet. To these are fixed the radiating plates P, having holes punched in the outer end for bolting on the first part of the permanent work, viz., the inner angle A of the circular stiffening girders. The same bolts are also made to carry the web plates W of those girders, on the outer edge of which is fixed the angle iron I for making the final connection to the shell of the tube. The horizontal H beams H are now placed in position, being securely bolted through the inner angle of the circular girders. On these beams are now placed the shell or tube plates S, the ends forming butt joints, while longitudinally they lap one another, this taking place over the solid flange of the H beams. The end joint of the one plate breaks opposite the centre or solid part of those on either side.

The first plates to place in position are the inner, or those lying close against the flange of the beams, beginning generally at the bottom, and coming up on each side. Owing to the passing of the one plate beyond the other, one half of each remains free to put

THE FORTH BRIDGE; PLATE-EDGE PLANING MACHINES.

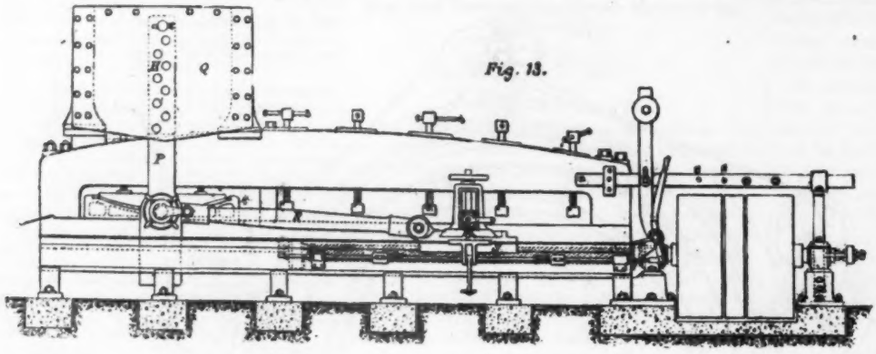


Fig. 13.

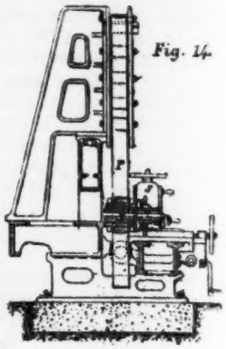


Fig. 14.

grabs and draw-washers on, without interfering with the placing of the outer ones in position. So soon as the outer ones have been put on, and fixed in a similar manner, there is passed round all a couple of angle iron rings, for binding and drawing them up to their proper position. The tightening up is done by means of iron wedges, between the plates and the rings. After the bottom plates have been fixed in position, the tube is borne up by wooden blocks, built between it and the cradle underneath,

The true position of the tubes, both as regards horizontal distance apart and height, is found by means of a theodolite, placed at one end of the roads, on a fixed platform, in a position such that when it is in line with a stationary point at the other end, it always fixes the centres 120 feet apart throughout, and horizontally in the same plane. If the centre of the mandrel is not in this line, then it is made so by being raised, lowered, or shifted sideways to suit. When the mandrel is right, the tube must of necessity be so also, seeing the centres coincide.

When the building of one ring of plates has been completed, the drilling machine is moved forward, the blocks in front being taken out of the way, and rebuilt behind, as it is travelled along. To enable the drilling to go on continuously, the building of the tube in front is being proceeded with, while the machine is still at work on the portion immediately behind. These tube-drilling machines of which there are four are shown by Figures 16 and 17. Each is self-contained, and on being run along the rails carries all with it. The principal parts are, the wrought-iron underframe or carriage A, on the one side of which is fixed the engine E and boiler B, and two large cast-iron rings C, firmly bolted to the main cross girders. These rings have an internal diameter of 13 ft., sufficient to enable them to pass freely round the tube, when the machine is being moved along. Five cast-iron slides D are fixed thereon, and held in position by means of small slipper blocks F, fitting into a recess in each of the rings C. On each of the slides are the two heads HH. Each head is provided with a single drill, and is capable of being rapidly run from one point of the slide to another by rack and pinion gearing. The slides are kept in position, and also turned round the rings C, in either direction, by means of two worms W carried in brackets F, one gearing in each ring in the circular racks R. These racks being bolted to the rings, serve also as guides for steadying the whole upper portion of the machine. All the drills point to the centre of the tube, and having, as shown, both a circular and longitudinal motion, they can with ease be made to reach every hole in any part of the structure, some of which are through a depth of as much as 4 in. of solid metal.

It might here be mentioned, that some of the slides were specially designed to overcome the difficulty of drilling, say, a flat part in any of the tubes. The difficulty lies in the fact that the drills on any of the fixed heads always point to the centre of the tube, whereas in the case just mentioned, the holes require to be drilled at right angles to the special or flat part. The mode adopted to overcome this was to make both ends of each slide circled, fitting them into separate heads, which in turn were bolted to the slipper blocks F, as in the others. On the head at one end is placed a worm, while on the same end of the slide there is keyed a wheel into which the worm is geared; by turning this the slide can be made to place and keep the drill pointing in any required direction.

The whole of the drills are fed into their work by an automatic arrangement, the motion being imparted to the longitudinal shaft L, by a band driven off the main driving pulley. On this shaft slides, and by it also are driven the worms W', necessary for turning the wormwheel I, which at will can be made to drive the handwheel R, thereby feeding the drill into its work. At one end of each of the main slides is overhung the driving pulley, P the power being transmitted from the engine to the whole of these by means of a cotton rope, guided where necessary by supplementary pulleys. The slack is taken up by a shifting quadrant Q, moving about the engine shaft as a centre, assisted by auxiliary pulleys on the wrought-iron frame close by the engine.

When starting work on any tube, a drilling machine is moved forward to the point at which operations are to begin. Each of the five slides is now moved round the rings until the points of the drills face truly any series of

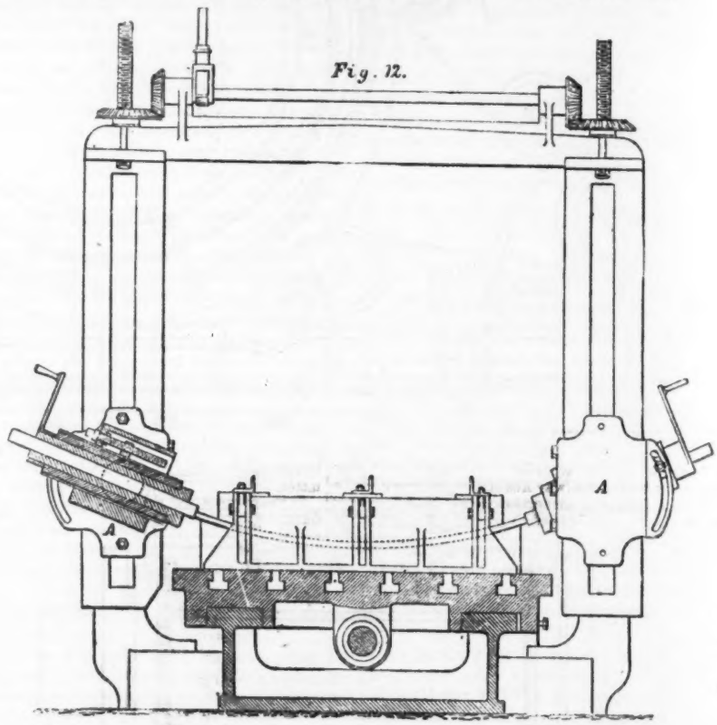


Fig. 12.

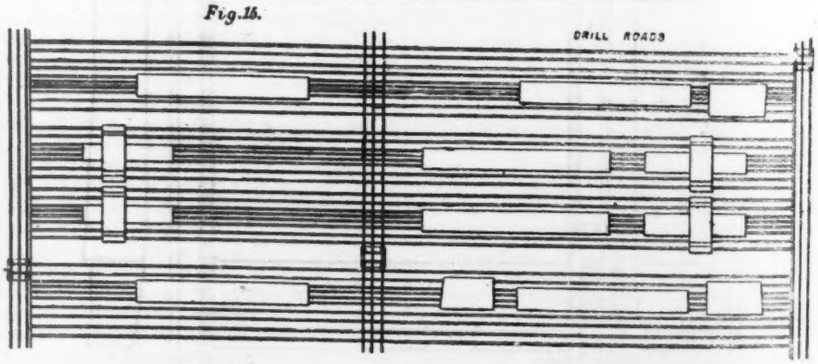


Fig. 15.

holes in the longitudinal beams. The holes in this line, or series, are all drilled, two drills being at work on each line; then the slides are again placed so as to suit a new set, and so on until the whole of the tube commanded by the machine in its present position is finished. This is equal in length to 8 ft., and includes the full circumference of the tube. The number of holes in such is about 800, and the time required to drill all, when working continuously, is from 24 to 28 hours, varying thus much principally on account of the difference of thickness of the various parts of the tubes. The machine is in like manner made to drill the whole length of the tubes.

At several of the ends of the first four of these tubes there are at present being erected the skewbacks, each a complicated connection of five different tubes, including one end of these just described, and also several heavy bracing girders. Into this, however, it is not proposed to enter at this time. At present other tubes are being treated in a manner similar to that already described, which shows if anything is yet required, that special work can only be grappled with to advantage by the free use of special plant.

FORTH BRIDGE RAILWAY.

The following is the seventh quarterly report of the inspection by Major-General Hutchinson, R. E., and Major Marindin, R. E., of the works in progress for the construction of the bridge over the River Forth.

RAILWAY DEPARTMENT, BOARD OF TRADE,
1, WHITEHALL, LONDON, S, W.
December 1, 1884.

Sir,—We have the honor to report, for the information of the Board of Trade, that in compliance with the instructions contained in the order of the 26th October, 1882 (R. 10, 354), and in accordance with the provisions of the Forth Bridge Railway Act of 1884, we have made our Seventh quarterly inspection of the works in progress for the construction of the bridge over the River Forth at Queensferry.

These works have been materially advanced since our inspection at the end of August, their progress during the quarter and their state at the end of November being briefly detailed below.

TEMPORARY WORKS.

At South Queensferry.—The cofferdam for the last viaduct pier, No. 9, has been completed and pumped out. The masonry of No. 8 viaduct pier, and of the south cantilever pier being now above high-water level, the dams at these places are being removed. The staging for the erection of the south viaduct girders has been completed for five spans. Two additional storage reservoirs for water have been constructed, one at Dalmeny Oil Works, where the water is pumped, and the other on the works.

In the shops eight radial drills, a second 8-spindle bed-plate drilling machine, a second universal hole-cutting tool, a third 7-ton travelling crane for the drill roads, a 60 horse-power pair of engines for electric lightning, and several smaller machines and tools have been added. One of the workshops has been and the other is being enlarged, while additional roads are being made for drilling both the tubes and the cross girders.

At Inch Garvie.—The construction of the staging which is to cover the space between the four piers is progressing, 34 columns and 622 feet of girders being now in position, and the landing stage also has been extended.

At North Queensferry.—The cofferdam for the foundation of the south-east pier has been completed, and the benching of the rock commenced. This dam, which is a whole-tide dam, has given considerable trouble, and, owing to leaks, either through the dam itself or through fissures in the rock, it has up to the present time been impossible to empty it by pumping. Work is in progress to make it tight, by means of cement.

PERMANENT WORKS.

At South Queensferry.—The masonry of viaduct pier No. 7 has been raised 15 feet to the level at which the girders are to be put together, viz., 27 feet above O. D., and that of viaduct pier No. 8 has been carried up to 27 feet and now stands at 17⅞ feet above O. D. At the south cantilever pier the masonry has been raised 20 feet and is now at coping level, some of the coping being already set. The construction of the viaduct girders on the south side has been commenced, the lower booms of three spans having been rivetted up, and a few of the diagonals erected.

At Inch Garvie.—The masonry of the north-east pier has been completed, except a few of the capping stones. The caisson for the north-west pier, having been successfully sealed to the rock by concrete and cement, now forms a half-tide dam, and is pumped out at each tide. It was emptied for the first time on the 23rd October, since which date the benching of the rock and the building up of the masonry have proceeded steadily; the tie-rods securing the lower permanent part of the caisson to the rock have been fixed, and the masonry at the deeper part of the foundation has been built up about 10 feet, or to within 7 feet of low-water level.

At North Queensferry.—The masonry of the Fife south-west pier has been completed, except a few of the capping stones, and the lower bedplates of the north-east and north-west piers have been rivetted up.

The viaduct girders for one span, with cross-girders, floor, hand-rail, etc., are all but completed; those of a second span are more than half finished; and the lower booms of a third are in hand.

GENERAL REMARKS.

The first of the large caissons for the Queensferry main piers, that for the south-west pier, has been sunk under air pressure through 41 feet of mud and clay, and the cutting edge at the bottom is now within 3½ feet of its permanent level, viz., 62 feet below O. D. Progress through the last 20 feet of ground has been slower than was anticipated, owing to the very hard and tough nature of the blue boulder clay, which was excavated with much difficulty, and is now being got out by means of hydraulic spades specially designed and admirably adapted for the work. At the present rate of progress this caisson should reach its final level in the course of a few days, when the air-chamber will be filled with concrete or rubble masonry, and the air locks removed.

The second caisson, that for the south-east pier having been loaded with about 3600 tons of concrete, air pressure was applied on the 22nd November, and the mud in the air-chamber is being removed by the ejector.

The third caisson, that for the north-east pier, has been successfully launched, and secured at its permanent site with 3400 tons of concrete in it; and the fourth caisson has been built up on the launching ways to a height of 43 feet, and will be launched in a few days.

The erection and rivetting up of the first of the two deep-water caissons for Inch Garvie have been commenced on the south shore, and the second will be built on the launching ways at present occupied by the fourth Queensferry caisson, after the launching of the latter.

In the shops about 5,000 tons of plates, ties, and angles have been delivered, and about 1,750 tons are ready for erection; the whole of the bed plates (four lower and four upper) for the Fife piers are now finished, and three lower plates for the Queensferry piers are in hand; two Fife skewbacks are well advanced, and a third is being commenced; the vertical columns for the Fife piers are completed for a height of 80 feet, and those for the Queensferry piers are in progress, and the diagonal struts for the Fife piers, and the third of the lattice girders connecting the skewbacks transversely to the center line of the bridge are also in hand.

About 202,000 cubic feet of granite have been delivered, of which 142,000 cubic feet have been set; about 32,000 cubic yards of concrete and rubble masonry are in position, and about 8500 tons of cement have been used.

The number of men at present employed on the works is about 1850.

In conclusion, we are glad to be able to report that, so far as we are enabled to judge, there is no falling off in the character of the work, which continues to be very good, and that the completed foundations for the large piers below water, all of which we have personally inspected, are satisfactory.

Of these foundations opened since our last inspection, that for the north-west pier at Inch Garvie is upon the solid rock, and that for the south-west pier at Queensferry is upon a very hard boulder clay, similar in character to that upon which the south cantilever pier is founded.

We have, &c.,
C. S. HUTCHINSON, Major-General, R. E.
F. A. MARINDIN, Major.

The Assistant-Secretary,
Railway Department, Board of Trade.

TO CLEAN IVORY RULES AND SCALES, rub with a new soft tooth brush, soap, and tepid water: then dry the ivory, and the brush, dip the latter in alcohol, and polish the ivory until it has regained its former polish. If the water has given the ivory a yellowish tint, dry in a heated place. If the ivory has grown yellow with age or careless handling, it can be bleached by placing it under a glass bell, with some chloride of lime and muriatic acid in a small vessel, and setting the whole thing in the sunshine. Care must be taken not to inhale the fumes of the acid. The bleaching properties of the chlorine destroy the yellow coloring matter in the surface of the ivory, and it resumes its original white tint.

The Theory and Calculation of Earthwork Slopes.*

Written for ENGINEERING NEWS.

BY MANSFIELD MERRIMAN, M. AM. SOC. C. E.
Prof of Civil Engineering at Lehigh University.

Continued from Page 174.

4. CONSTRUCTIONS IN LOOSE EARTH.—The last article shows that in building an embankment of loose earth it is necessary that its slope or angle of inclination to the horizontal should not be greater than the angle of repose. In making an excavation it is often possible on account of the cohesion of the earth to have its slope at first greater than the angle of repose, but as the cohesion disappears under atmospheric influences the particles roll down and its slope finally becomes equal to φ.

The following table gives rough average values of the angles of repose and coefficients of friction of different kinds of earth. In the fourth column the natural slope is expressed in the manner customary among engineers by the ratio of its horizontal to its vertical projection. In the last column average values of the weight of the material are given.

Kind of Earth.	Angle of Repose. φ	Coefficient of Friction f	Natural Slope	Weight	
				Kilos per cu. met.	Pounds per cu. ft.
Gravel round	30°	0.58	1.7 to 1	1600	100
Gravel sharp	40	0.84	1.2 to 1	1760	110
Sand dry	35	0.70	1.4 to 1	1600	100
Sand moist	40	0.84	1.2 to 1	1700	110
Sand very wet	30	0.58	1.7 to 1	2000	125
Earth dry	40	0.84	1.2 to 1	1440	90
Earth moist	45	1.00	1 to 1	1520	95
Earth very wet	32	0.62	1.6 to 1	1840	115

It will be noticed that the natural slope and specific gravity of earth undergo quite wide variations as its degree of moisture varies. In collecting data for the discussion of particular cases it is hence necessary to determine limits as well as average values.

5. LAWS OF COHESION. Cohesion is a force uniting particles of matter together. If, for instance, two surfaces have been for some time in contact, they become to a certain extent glued or fastened together so that any attempt to separate them is met by a resistance. Friction only resists the separation of surfaces when motion is attempted which produces sliding, but cohesion resists their separation whether the motion be attempted parallel or perpendicular to the plane of contact. Particles of rock are held together by strong cohesive forces, while particles of dry sand have little if any, cohesion.

By experiment the following are found to be the laws of cohesion: first, the force of cohesion between two surfaces is directly proportional to the area of contact; second, it depends upon the nature of the surfaces, and third, it is independent of the normal pressure. These laws may be expressed by the equation.

$$C = c\,A. \qquad (3)$$

in which C is the resisting force of cohesion between two surfaces, A the area of contact, and c a quantity called the coefficient of cohesion depending upon the nature of the material.

TO BE CONTINUED.

AT Trinidad, in Venezuela, is a petroleal phenomenon, the so-called pitch lake, south of Port of Spain. The lake is a cavity containing a concrete and slightly flexible mass of pitch, on a level and swampy plain. The pitch is porous, never plastic, and yet the hole dug fills up level in a short time. The lake has an area of about 100 acres and a depth unascertained. There are some 50,000 tons dug out in a year. The Government owns the lake and leases it to three parties, viz.: Thomas Field, of New York; C. F. Stoelmeyer and T. A. Finlayem & Co.

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"ENGINEERING DRAWINGS AND DATA," are selling at the rate of one hundred copies per week. There was some delay on account of the Tables of Prices and Bids, but we can now fill orders up to the limit of the edition. The new Croton Aqueduct is one of the most important engineering works now in progress, and everything connected with it is of interest, and as the work progresses, this interest will grow. The Commission in letting the first contract, published two large books of drawings along with the specifications; these were sold for $20 for the two, and contractors and others desiring them had to buy. For our own copies we paid that amount. Of these there are no more copies, but "Engineering Drawings and Data" comprise all the essential plans of the work and are reproductions of the official copy. They are, moreover, preferable on account of the more convenient size, 11 by 14 inches, and the low price places them within easy reach of every engineer and contractor. The specifications are published in ENGINEERING NEWS of March 7th and 14th and cannot be had elsewhere. The price for the drawings alone is $2.00, and with two copies of ENGINEERING NEWS it is $2.20.

THE late experiments with shells charged with nitro-gelatine, at Washington, D. C. open up vast possibilities in offensive and defensive warfare. According to the press reports, six-inch shells were used carrying a bursting charge of 11 lbs. of nitro-gelatine. The second shell fired against a ledge of trap-rock, at 1,000 yards range, opened a cavity in this rock "25 feet in diameter and 6 feet deep."

This is rather hard to believe without some official report upon the subject; but, if true, we see little use in "iron-walls" as a necessary adjunct to the navy of the future. The one fact however to be gathered from this trial is, that it is at last possible to fire a shell charged with nitro-gelatine without exploding it in the gun by the initial shock of the propelling charge. This end is attained in the Snyder system by the interposition of an elastic buffer between the shell and the powder charge. The gun used in the experiments was a six-inch rifled breech-loading cannon of the Moffat pattern.

Water Supply in the Desert.

London *Engineering*, of March 6, has an editorial on the "Water-supply in the Desert." After describing the "Prout Route," illustrated in this journal, it gives the following information relating to the pipe to be used:—The water main is to be lap-welded, wrought iron pipe, ¼ inch thick and 4 inches in diameter, connected by an external, threaded sleeve 5 inches long and ½ inch thick. Each pipe and sleeve is tested to 1800 lbs. pressure before use. About 80 miles of this pipe were then nearly completed at the works of Messrs. Andrew and James Stuart, Coatesbridge, and Russell & Co., Walsall. The Worthington Pumping Engine Co. had already delivered some of the pumps at Woolwich.

Engineering comments on the dissatisfaction of English makers at the award of the pump contract to an American firm, by saying that the general contractors would have "failed in the first element of prudence had they not gone to those makers who have had the greatest experience in this special class of machinery." The military operations between Suakim and Berber depend for their success upon this water supply, and "the existence of an expedition would be imperilled by any breakdown."

Mr. Tweddle, one of the contractors has had extensive practical experience in the transport of petroleum by means of pumps and pipe lines, in the United States and in Russia. It seems that Mr. Tweddle suggested the pipe line to the War Office about a year ago; and, at his own cost, constructed a line 2½ miles long at Aldershott from a canal to the top of Beacon Hill. The results of this experimental line were so satisfactory that the system was ultimately adopted and the work intrusted to Mr. Tweddle.

It appears, from the editorial quoted, that water is to be supplied to the troops through the pipe line about as fast as the pipe is laid. As they must start from Suakim, where only a very limited quantity of water is obtainable at present, the query arises as to the source of this water supply. The English papers are silent upon this subject, and as Suakim is now suffering from a scarcity of rain and ground water, condensation of sea-water at the cost of a considerable consumption of scarce fuel seems to be the only means available.

The engineering and trade press of England generally seems to be unduly exercised over this Suakim-Berber pump contract; the *Engineer*, unlike its contempory quoted above, gives utterance to the following philippic, given in full as indicative of the present feeling on this head among Englishmen:

"But we should like to know why the contract was let to an American at all, and why a single penny of the money paid by the British tax-payer should be sent out of the country.

"The great advantage that Great Britain possesses over other nations in carrying on warfare is that she has nothing to pay to foreigners for the greater portion of the munitions of war. Thus the money spent on ironclads is virtually taken out of one of John Bull's pockets to be put into another. But warfare will assume a totally different aspect if British taxes are to be employed to enrich the rival manufacturers of other countries while our own artisans lack bread."

Iron, of the same date of March 6, also scolds the "grandmotherly government" for sanctioning the shipment of these pumps from America, and protests in the name of common fairness against orders being given by the English government to a foreign country for machinery required for the British army. It suggests that the entire matter should be referred to the House of Commons and a peremptory stop be put to this American outrage on English manufacturers.

All this is very patriotic, and it is very characteristic of the Englishman's exceeding great care for his own interests in trade. It may be natural and commendable, but we doubt if it is a sensible course to pursue in this especial case, and with the surrounding conditions. *Engineering* strikes the proper key when it notes the importation of these pumps as being simply an act of common prudence on the part of the contractor. Mr. Tweddle, who is said to be an American, by *Iron*, suggested the pipe-line, practically proved the feasibility of the scheme, aud is made responsible for its ultimate success. Money considerations alone would induce this contractor to adopt the tried and proven machinery as against any other. The success or failure of a most important military movement depends upon the practical and efficient working of this pumping plant, and a break down in that may mean life and money both wasted; these being incontestible facts, he selected engines that were daily doing exactly similar duty on American oil-lines, instead of indulging in experimental British machines. A wise Englishman would have done exactly the same thing, though a very patriotic Englishman would probably have tried British engines and British pipe at any hazard.

Iron accuses the government of a lack of "business capacity" in permitting this thing, and declares that British pumps are "working satisfactorily" in the Caucasus. In the first place, we don't see what the British, or any other government, has to do with a contractor's plant, so long as it is acknowledged to be thoroughly efficient for the work in hand; and we also think that the English War Office has given evidence of a "business capacity" very unusual, in this case, if the conduct of the Egyptian campaign to date be taken as a standard. We take the word of the paper quoted for the satisfactory working of the British pumps in the Caucasus; but, by their own admission, the Russian oil-line referred to is only 50 miles long and the elevation overcome is 1200 feet. The Suakim—Berber scheme, with its 240 miles and 3,000 feet of rise, is an entirely different affair, and the English pumps might have imperilled the whole expedition by failing to work "satisfactorily" when it was too late and impossible to remedy their failure under the, to them, untried conditions. It would be folly for any contractor, American or English, to take the chances; and it is the height of folly to offset British self-interest against the possible fate of an army of brave men, their own fellow-country men.

Orange, Water and Sewerage.

The multiplicity of Oranges in New Jersey, led to a mistake in our last issue which has we fear misled some of our readers. The city of Orange has not yet moved officially in the matter of sewerage, although it has had a plentiful water supply for a couple of years. The authorities of the adjoining town of East Orange are the ones which have had their sewer system reported upon by Mr. Croes, and it was to them that the paragraph last week was intended to refer. At the town election held on the 12th inst. the question of sewerage was voted on, and out of 1086 votes cast, 596 were in favor of constructing sewers and 490 opposed to it. In the Ashland district which pays two-thirds of the taxes of the town, the vote was 460 in favor and 99 against, so that it is probable that East Orange will have sewers before long.

The action of their neighbors has stirred up the citizens of Orange city, and a public meeting has been held at which it was decided to request the Common Council to have the question of sewerage for the city examined into.

To Book Buyers.

In answer to a number of queries concerning some of the newer books on engineering subjects, which we have lately noticed, we make the following explanations and replies:

The "Engineering Drawings and Data, Part I," is a volume complete in itself, and issued for the price named. It is a photographic reproduction of the plans supplied to the bidders on the new Croton Aqueduct for the sum of $20, the purpose of which plans was to assist the contractors in estimating upon the probable cost of the proposed work by furnishing them with cross-sections, etc., of every possible contingency of construction. They are full working drawings, but they may, or may not be used as the actual work is developed. This volume is "Part I," because it is proposed to follow it up with other volumes of like nature, showing anything new that may arise in the detail of this important work, and upon other engineering structures. It is the present purpose of its authors to give the engineering working drawings of some first-class, modern railway in all the minutiæ of masonry and bridge construction; elevated railways, etc. The especial features of this series will be the reproduction, in exact facsimile, and in a convenient form, of the detailed plans of important structures, in a shape seldom accessible to the student in engineering.

"Trautwine's New Edition" is promised positively by the publishers within the next two weeks. The delay in its issue has been unavoidable, and is the direct result of the very conscientious and painstaking labor the author is putting upon it, to bring it abreast of the rapid advances in engineering. The volume, in its old form, was a very encyclopædia of the profession of civil engineering, and we know that engineers can appreciate the labor involved in its revision. But from the advanced sheets seen by us, we promise them full compensation for their patience. The constant demand for the work from those who only know it in its original shape, is earnest sufficient of its value, and the popular appreciation of Mr. Trautwine's life work; and it is this demand that has spurred the present author to a further perfection of the text so as to bring it fully up to date, and add necessary new matter.

To inquirers after the "latest work on bridge design and construction," we again refer them to Prof. Du Bois' "Strains in Framed Structures," and to the "Designing of Ordinary Iron Highway Bridges," by Prof. Waddell. We have fully noticed both of these works, and it is not necessary to repeat our notice here. In this same direction, we will have ready in a few days, "A General Specification for Highway Bridges and Trestles," prepared by Theodore Cooper, the well-known consulting engineer of this city. This specification is the result of most careful study on the part of an acknowledged expert, and must be valuable and welcome in supplanting the many crude and inefficient productions now afloat under the name of highway bridge specifications. The same author has now in press a second edition of his well received "General Specifications for Iron Railroad Bridges and Trestles," covering every condition of modern construction.

To those writing for books on American water-works' construction, we would recommend the revised edition of Mr. J. T. Fanning's "Treatise of Water-Supply Engineering." This is the only work treating fully on this important question as practiced in this country. The "Statistical Tables" of Mr. J. James R. Croes, just published by this journal, gives more of the history, cost, system, consumption, etc., of American Water-Works than elsewhere published ouside of our own pages. About one thousand established works are given, and the "Tables" represent an amount of labor, in collecting the data, and putting this into a useful shape, that should make hydraulic engineers, and all interested in this important branch of the profession indebted for all time to its industrious and painstaking author.

Water Works Statistics.

EVERY Engineer and Superintendent of water works knows the difficulty of getting data concerning the construction and operation of works similar to his own, and he also knows that he is overwhelmed with circulars from his fellow superintendents, asking all sorts of questions, to which he has not the time to reply, and from which he would derive no benefit if he did, as few of those who ask questions give the benefit of their investigation to the public.

For four years, ENGINEERING NEWS has been striving to obtain data concerning the water-works of the United States which will be of interest to the large and constantly increasing class of water-works builders and managers. The fullest statistics of water-works construction and operation which exist in the World, we believe, are to be found in the series of descriptions of American Water-works, by Mr. Croes, which have been published weekly in our columns since March 1881.

We issued in 1883 a compendious summary of the chief statistical items of interest in book form, which met with so much favor that we have just issued a second edition of the work, which contains the latest possible returns from 1,008 towns. Of about 200 of these, it is true that we have little more information than the fact that there are water-works there. The officers either have neglected to reply to Mr Croes's inquiries or have sent the most meagre data. But even with these drawbacks, the "Statistical Tables of American Water-works" is a book of inestimable value to every one who either manages works, constructs them, or is anticipating taking an interest in them.

The policy we have pursued of sending gratis to every one who furnishes information a copy of the work has resulted in obtaining fuller data than before, and has also inspired the shrewd business men who manufacture and deal in supplies for water-works to insert their business card in the advertising pages appended to the book, so that this "second issue" is not only a compendium of information as to cost, operating expenses, pipe mileage, number of hydrants and consumers and amount of water used, but also a directory of the most reliable and experienced designers, constructors and suppliers in all matters relating to water supply.

During the coming year, it is our intention to continue the publication of the descriptive articles by Mr. Croes and issue them before long in separate form. In the meantime, the "Statistical Tables" for 1885 will supply a want greatly felt, and as the demand for them is already great, those who desire a copy should apply early. The "free list" is already exhausted.

REMOVING TOWN REFUSE.—One of the most important innovations during the year is the new method that has been adopted in Vienna of collecting and removing town refuse. In place of doing this in open carts as heretofore each household is supplied with a barrel with a close-fitting lid. When this is filled, the lid is well fastened on, the barrel placed on the cart and removed to the place appointed, without the possibility of any household dust and filth, impregnated with disease-germs, being blown about, and possibly disseminating disease along the line of route.

ENGINEERING NEWS three months for One Dollar.

Engineers' Club of Philadelphia.

Record of business meeting, March 7th, 1885; 50 members present.

The Tellers of Election of Members reported that the following gentlemen had been elected Active Members of the Club: Messrs. A. W. Sims, Percy T. Osborne, A. H. Storrs, Wm. O. Dunbar, Morris P. Janney, John W. Henderson, Arthur H. Howland, P. D. Ford, and J. H Nichol.

Mr. William Wharton, Jr., read a comprehensive paper on the Construction of Street Railways in the United States, and exhibited, in connection with the same, a number of varieties of street rails used in different cities on straight tracks and on curves; also the usual method of construction with wooden ties and wooden stringers, and the Johnson system and the Brayton system of street railway construction, in both of which the use of wood is entirely dispensed with.

He showed, by the working of a model, the system of transferring cars on the six tracks of the Brooklyn City Railroad Company, at their terminus near the east end of the New York and Brooklyn Bridge, designed by him some two years ago. The moving of the cars from one track to another is automatically effected by gravity alone. The car moves down grade on to a truck, which latter is started by the weight of the car down an inclined plane at right angles to the line of car tracks, and stops opposite the track upon which it is desired to shift the car. After being relieved of the car, the truck returns, by action of counterweight, to its original position, and is ready for the next shift.

Mr. C. G. Darrach submitted his informal discussion of the Repairs to Chestnut Street Bridge, Philadelphia, which he had offered at a previous meeting, but which he had desired to be withheld from the minutes until Mr. Titlow's paper was presented. Mr. Darrach said:—

"Relative to the article in the *Railroad Gazette* on the repairs to the western abutment of the Chestnut Street Bridge, to which our attention has been called by Mr. d'Invilliers, I would state that there are some errors, as well as some omissions, in the description of the failure.

1st. The west abutment of the 53-foot span is at present concave, and not straight as shown.

2d. A very decided crack or break in the retaining wall on the south has developed next to the buttress. This crack runs from 0 under the coping to 5 inches in width at a level with the spring line of the arch, and is nearly parallel with the face of the end of the abutment, *showing clearly that the masonry has been forced eastwardly*.

The width of this crack corresponds with the shortening of the span.

3d. The crack in the soffit of the arch is wider at the springing line than near the crown, showing that the abutment has spread.

These points of failure show that the end foundations of the ends of the abutment have been pushed to the N. E. and S. E. In addition, the bed of the skewback on the south end is badly crushed. The stones in the abutment under the skewback are badly spalled under the *rear* of the skewback.

In the absence of absolute measurement from a *fixed* point, I am not prepared to say that there has been no movement of the abutment of the iron span westward, as the failure of the west abutment of the 53 ft. arch would relieve the pressure exerted by its arch against the 60 ft. arch and the abutment of the iron span, allowing the thrust of the iron span to act against its abutment supported only on piles driven in mud.

I am convinced that the *first cause* of the trouble is in the foundations of the western abutment of the 53 ft. span; and also that, while the repairs now being made will coun-

teract a tendency of movement in the abutment of the iron span westward, they are only good as a precautionary measure in view of the repairs which have not been finished, and in fact hardly begun."

The Secretary presented, for Capt. P. C. F. West, a paper upon Isthmian Transits, in which Capt. West, who has had large experience in the region, especially treats of the lack and necessity of harbors at the termini of the routes.

Mr. Geo. S. Strong presented some notes upon recent Locomotive Construction, showing blackboard sketches of indicator cards.

Messrs. James R. McClure, Joseph Johnson and John H. Dye, Chairman, the Committee on Memorial of Mr. D. Hudson Shedaker, our late fellow-member, presented a sketch of his life and professional labors. He had occupied many prominent positions, one of the principal of which was that of Surveyor and regulator of the important Third Survey District of Philadelphia, which embraces the old city proper. "How well he performed his duties and with what satisfaction to the people, is evidenced by his election and re-election for four successive terms. He was warm in his friendship, kind and courteous in his intercourse with his fellows, honest and upright in in all his dealings, a good citizen and a kind friend. He has finished his work and gone to his rest. Peace to his ashes!"

Howard Murphy,
Secretary and Treasurer.

The Civil Engineers Club of Cleveland Ohio.

The Civil Engineer's Club of Cleveland held its fifth annual meeting at the Stillman House, Cleveland on March 10. The following officers were elected for the coming year:

President, J. F. Holloway; Vice President, Charles Latimer; Corresponding Secretary, E. H. Jones; Recording Secretary, M. W. Kingsley; Assistant Recording Secretary. F. C. Bate; Member of the Boad of Managers of the Association of Engineering Societies, M. E. Rawson; Treasurer, S. J. Baker.

President Holloway in his annual address reviewed the growth and progress of the Club, and stated that the present membership was 134; the club, during its short existence has done important work in the shape of contributions from its members, and financially, socially and professionally it has been a most satisfactory success. Mr. Holloway then referred to some of the more important engineering works of the last year, and especially to the part that American pumping machinery is to play in battling with the False Prophet in ancient Egypt.

After the business of the annual meeting had been disposed of the members present sat down to a bountiful and well served banquet. A number of speeches followed, from Genl. D. Legget, C. P. Leland, Saml. Briggs, Charles Latimer, Dr. Pomeroy, and others.

Michigan Engineering Society.

The Annual Convention of the Society was held at Lansing, Feb. 17 to 22, 1885. The weather was bitterly cold (the mercury falling every night from ten to twenty-two below zero) and followed a week of deep and drifting snow storms, that rendered the movement of railroad trains very uncertain.

These circumstances no doubt affected the attendance to a great degree, yet from fifty to seventy-five were present at each session.

Many telegrams and letters were received from absent members, indicating at least a deep interest in the meeting. The following programme was fully, carried out the papers read being of unusual excellence. After each paper a sharp discussion drew out the opinion of each member regarding the points read in the paper. The following is the programme:

Pioneer Rooms, State Capitol Tuesday, Feb. 17, 2 P. M.

Suggestions by the President, Report of Executive Committee. Report of the Treasurer. This report showed a prosperous year for the Society, and that, excepting for the Manual Committee, the receipts had fully balanced the expenses.

The cash on hand was fifty dollars. The number of members of this society, one hundred and fifty.

T. T. Watkins, Chairman of the Committee on Roads, read a report outlining the work needed to put our roads in good condition. M. S. Cook, of Manistee, was to have read a paper on "Subdivision of Sections," but owing to an accident to his train was not present until Wednesday. His paper was read on Thursday. No other breaks in the programme occurred.

Public Meeting at City Council Room. Tuesday, Feb. 17, 1885, 7.30 P. M.

Address of the President, Prof. J. B. Davis of Ann Arbor. The Engineer; What sort of a man is He?

Pioneer Room, Capitol, Wednesday, Feb. 18, 9, A. M.

Paper.—Estimating the Amount of Value of Standing Pine Timber. S. S. Hastings, of St. Louis.

Paper.—Practical Queries. I. H. Leavenworth, Saginaw City.

2 P. M.

Paper.—Construction of Iron Lighthouses. W. S. Russell, Detroit.

Report of Committee on Manual,

Paper.—The Separate System of Sewerage. Geo. S. Piersons, Kalamazoo.

Public Meeting, Legislative Hall, 7.30 P. M.

Paper by Professor C. E. Greene of Ann Arbor, on a system of Water-Works Designed for Ann Arbor.

Lecture by W. R. Coats of Kalamazoo, on Developement of Water Supply.

Pioneer Room, Thursday, Feb. 19, 9, A. M.

Paper by Dorr Skeels, Grand Rapids. Suggestions to beginners in Land Surveying.

Paper by H. C. Pearsons, of Ferrysburg. Cause of Compass Deviations on Vessels.

Report of Committee on Exhibition of Instruments.

2 P. M.

Paper by E. Treadwell, of F. & P. M. R. R., East Saginaw. Maintenance of Way on Railroads.

Paper by F. P. Davis, Washington, D. C. Location of Canadian Pacific, Rocky Mountain Division.

7.30 *P. M.—Public Meeting.*

Address by Hon. I. S. Montague, of Howell. Legal Position of a Surveyor in the State of Michigan.

Paper by Hon. Geo. E. Steele, Traverse City. Legal Requirements for Village Plats.

Pioneer Room, Friday, Feb. 20, 9, A.M.

Paper by Prof. R. C. Carpenter, Lansing. Construction of Chimneys for Steam Works.

Paper by James Wiseman, Lansing. The "Indicator" as Used on English Steamships.

Discussion on Balancing Engines. Jesse Smith, Detroit; S. E. Jarvis, Lansing.

2 P. M.

Address by M. E. Cooley, of Ann Arbor, Professor of Mechanical Engineering, University of Michigan.

Paper by W. S. Russell, Detroit.

Public Meeting, Legislative Hall, 7.30 P. M.

Address by Edwin Willits. Need of Technical Education.

The report of the Committee on Manual was made in part by each member, G. E. Steele of Traverse City; Frank Hodgman, of Climax; and Prof. C. F. R. Bellows, of Ypsilanti. The Manual is nearly ready for publication; it will be made so as to answer as a hand-book for surveyors, containing tables, United States and State Court decisions, and concise rules for all classes of surveying. It will be of value to Surveyors in all parts of the country.

W. B. Sears, Chief Engineer of the F. & P. M. R. R., read an excellent paper on "Roads and Bridges."

As shown by the programme, Friday was donated to papers in the interest of Mechanical Surveying. This branch of the Society promises to become in time, as strong as that of the Civil Engineers.

The next meeting of the Society will be held in Ann Arbor.

The proceedings will soon be published giving the papers and discussions in full.

B. T. LaRue, of Jackson, acted as Recording Secretary.

The following were elected members of the Society:

Jerome Allen, Surveyor and Engineer, Milan, Monroe Co.; Wm. P. Appleyard, Architect and Engineer, Lansing; Herbert Barber, U. S. Assistant Engineer, Highland; Horace Barnard, Railroad Engineer and Surveyor, Huron, Dakota; H. F. Bean, Civil Engineer, Tucker, Mich.; C. S. Breckinbridge, Sewer Engineer, East Saginaw; Wm. A. Campbell, Mechanical Engineer, East Saginaw; Lauir G. Carpenter, Assistant Professor of Mathematics, Lansing; A. L. Chappell, Surveyor, McBrade, Mich.; Addison Childs, Mechanical Engineer, State Capital, Lansing; Jackson Clark, Mechanical Engineer, Manufacturer, Hamel, Mich.; I. A. Cross, Civil Engineer and Surveyor, VanBuren Co.; E. Dennis, Mechanical Engineer, Manufacturer, Jackson, Mich.; G. W. Dane, Surveyor, Pine Run; Wm. P. Elliott, Mechanical Engineer, Manufacturer, Chicago; Geo. A. Fowler, Mechanical Engineer, Designer, Machine Shops, East Saginaw; O. C. Goodale, Surveyor, Chesaning, Mich.; E. W. Grand, Civil Engineer, Engineer A. T. & S. R. R. R., La Junta, Colorado; J. J. Granville, City Engineer, East Saginaw; Oliver S. Hoyden, Civil Engineer, Indian River, Cheboygan Co., J. W. Holmes, Civil Engineer and Manufacturer, Batavia, N. Y.; Chas. T. Howe, Mechanical Engineer, Ishpeming, Mich.; S. E. Jarvis, Mechanical Engineer and Manufacturer, Lansing; —— Logan, Mechanical Engineer and Manufacturer, Lansing; Prof. McLouth, Prof. Tavis, Professors of Physics, State Normal, Ypsilanti, Mich.; D. A. McLean, Surveyor, Malinas; Fred Morley, Civil Engineer, Ann Arbor; E. W. Muenscher, Civil Engineer and Surveyor, Grand Rapids, Mich.; E. S. Newton, Mechanical Engineer, East Saginaw; Wm. M. Porter, Electrical Engineer Brush System, Detroit, Mich., J. A. Sanford, Mechanical Engineer and Manufacturer, Jackson, Mich; Thos. E. Shaw, Surveyor, Presque Isle, Mich.; Jessie Smith, Mechanical Engineer, Detroit, Mich; H. B. Sturtevant, Mechanical Engineer, Ishpeming, Mich.; Job Tuthill, Civil Engineer, D. L & N. R., Ionia, Mich.; Geo. D. Walcott, Mechanical Engineer, Jackson, Mich.; H. D. Wicks, Mechanical Engineer, East Saginaw.

STOPPED HIS PAPER.—Once upon a time a certain man got mad with the editor and stopped his paper. The next week he sold his corn at four cents below the market price. Then his property was sold for taxes, because he didn't read the Sheriff's sales. He was arrested and fined $8 for going hunting on Sunday, simply because he didn't know it was Sunday, and he paid $3.00 for a lot of forged notes that had been advertised two weeks and the public cautioned not to negotiate for them. He then paid a big Irishman, with a foot like a forge hammer, to kick him all the way to the newspaper office, where he paid four years subscription in advance, and made the editor sign an agreement to knock him down and rob him if he ever ordered his paper stopped again. Such is life without a newspaper.

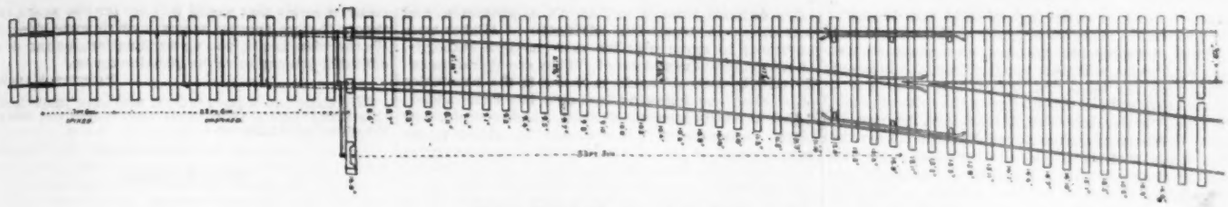

FIG 71. SINGLE TURNOUT, No. 8 FROG.

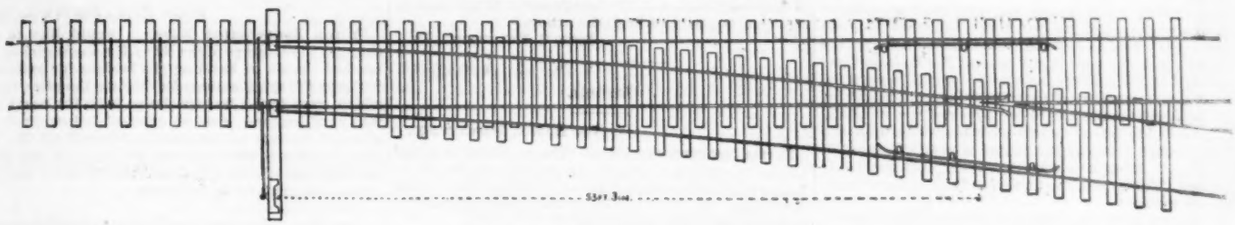

FIG. 72. No. 8. TURNOUT ON CROSS-TIES.

TRACK.*

BY W. B. PARSONS, JR., C. E.
ROADMASTER SUSQUEHANNA DIVISION ERIE R. R.

(*Continued from page* 172.)

From the head block both tracks are laid on one set of ties, varying in length according to the turnout curve, and carried to a point beyond the frog where the ordinary cross ties in each track can be put in without interfering with each other. On account of length these ties, called switch ties, are usually of sawed timber of any required dimension. But our previous remarks on cross ties apply equally to switch ties, and therefore hewn timber should be obtained if possible. As to cross sections, their thickness should be the same as that of the standard cross tie, and the breadth certainly not less than 8 inches for the lead rails of frogs in general use are laid to a sharp curve, and there being no elevation, they cut into the ties unless they have a good bearing. On account of the extra expense of handling and putting in place only the best white oak or timber capable of giving the longest possible life should be used. The length and number of these ties depend on the distance between the head blocks and the frog as given in table No. I. But this distance is governed by the frog angle or frog number, which must be explained before proceeding further.

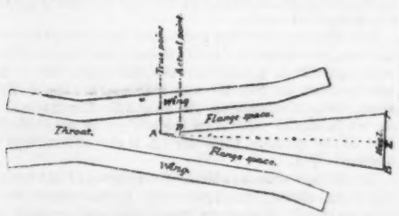

FIG. 70. OUTLINE DIAGRAM OF FROG.

Fig. 70 is an outline diagram of a frog. The angle is the divergence between the two sides of the point, that is the angle bounded by the two lines $B\ A$ & $A\ C$, and the number is the ratio of the base $B\ C$, and the perpendicular $A\ E$, or the number of times the heel of the point is contained in the length, which latter must be measured down the centre, and not along one of the sides. The number therefore, is greater as the angle is smaller.

For general use Nos. 10, 8 and 6 (or 6½), will be found most convenient. No. 10 is suitable for main track cross-overs, and all turnouts where trains are liable to run from 10 to 20 miles an hour. Even for this frog number the degree of curvature is over 6°, which since there is no elevation, is certainly as sharp as is admissable for such rates of speed.

For ordinary turnouts in yards, or where space is limited, and no high speed attempted, frog No. 8, whose curve is nearly 10° answers very well. Then, for those turnouts where great economy of room is necessary, use No. 6 (or 6½). These three numbers should cover all ordinary cases. For such frogs, spacing the ties 22½ inches between centers beginning with the head block which is equivalent to 16 ties to a 30 rail, the following switch ties will be required in order to have their ends line up on the turnout side, and project on both sides beyond the outer rail to the same extent as an 8 ft. cross tie in a single track:—

Table No. 2.	Switch ties	No. 10.	Frog 22½ in. centers.	
" " 3.	"	No. 8.	Frog	" " "
" " 4.	"	No. 6½.	Frog	" " "
" " 5.	"	No. 6.	Frog	" " "

(NOTE.—The tables are given in "Turnouts.")

In order to get lengths required to correspond with a cross tie of other size than 8 ft., it is only necessary to add to the figures given in the table the difference between the length of the cross tie in question and 8 ft. If it is inconvenient or not desired to use timber sawed so accurately, the ties in each set can readily be made into groups according to the nearest half or whole foot. Thus the No. 8 set would become: 3 ties, 8 ft., 6 in. long; 5 at 9 ft.; 4 at 9 ft., 6 in.; 3 at 10 ft., 10 ft., 6 in., 11 ft., and 11 ft., 6 in.; and 2 at every 6 in., from 12 ft. to 16 ft. inclusive.

Fig. 71 gives a complete plan for a No. 8 turnout, showing moving rails, switch rods, head block, spacing of switch ties, location of frogs, guard rails, ordinates, etc. It will be noticed that in these plans the distance from center of head block to frog point is given as 53 ft., 3 in., while table No. I puts it at 52 ft., 11 in. This difference is due to the bluntness of the frog point. The table is calculated to the "true" point, while in practice we have to measure to the "actual" point. (See frog diagram). This bluntness is generally ½ inch, so that the distance between the true and actual points of a No. 8 frog, is 4 inches. Sometimes, however, instead of these long ties, the ordinary switch ties doubled in past each other, as in Fig. 72 are used. This practice, except for temporary purposes is to be avoided. It is a waste of material, and it is impossible to get satisfactory results with the tamping when the ties are so close together.

(TO BE CONTINUED.)

NOTE: In our last week's article on "Track" the lamp cup in Fig. 69 is shaded so as to appear round; this is incorrect, as the lamp is really rectangular, and is made to slide in a groove as explained in the text. The bottom of this lamp cup is 4¾ x 3¾ inches.
ED. ENG. NEWS.

BELOIT, Wis., is entertaining propositions from parties desirous of building water-works. The contract made by the city two years ago with a company proposing to build, has been rescinded, as the company failed to carry out its terms.

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CORRESPONDENCE.

Beating the Bounds.

170, CLINTON STREET, BROOKLYN, N. Y.
March 10, 1885.

EDITOR ENGINEERING NEWS. I noted the paragraph in your paper a week or two ago referring to the old French custom of whipping boys to cause them to remember witnessing certain legal contracts. It may not be generally known to your readers that a somewhat similar custom (now entirely obsolete,) known as "beating the bounds," existed for many years in England On a certain day of the year the authorities of each parish, accompanied by the beadle and the chorister of the parish church, made a tour of the line of the parish boundary; the beadle being armed with a switch to whip the boys as they proceeded, so that the exact route of the boundary line might be impressed on their memories.

Where houses, etc., crossed the line, the boys were compelled to keep to it, climbing over or through the house, or other obstruction, (there were no ten or twelve story houses in those days:) and each boy was of course very anxious to keep in front, out of reach of the beadle's stick. Yours very truly,

EDWARD E. R. TRATMAN.

The Great Pyramid of Gizeh.

NEW YORK, March 16th, 1885.

EDITOR ENGINEERING NEWS.—The few words I have to say adverse to the claims of the Pyramidist, "that this structure embodies a heavenly devised system of weight and measure," is not with the hope of converting any one of the pronounced believers of that theory, to my own views of the matter—this attempt were only a little less absurd than the theory itself—but you have readers, who, with faith in the scientific ability of some of the advocates of the Pyramid theory, are disposed to accept results as given by these enthusiastic followers of a false prophet, without further study themselves of *books*, but perchance would read a paragraph of the ENGINEERING NEWS on this subject to some advantage to themselves, if it were reasonably short. What I have to say, was provoked by an article in your issue of Feb. 7th, p, 87, which reads as follows.

"Many mysteries and truths are claimed to be concealed in the Great Pyramid of Egypt. For instance, the base of the Napierian system of logarithms can be derived from the dimensions of the King's chamber and the coffer. The width of the former, is 206.3 inch or 10 cubits, and that of the latter, 36.65 inches, or 1.87 cubits, now if we write the equation 10, with an unknown exponent $x = 1.87$ and then compute the value of x, we are pleased and surprised to find that it is 0.2718, this is *one-tenth* of the base of the natural system of logs, which was unknown to science until discovered in 1614 by the genius of Napier."

The above would be more than curious if it were only true. Every alleged discovery of this kind in the great Pyramid, without exception, is sustained by the same, or a similar method of selecting dimensions from among conflicting measurements, and then subjecting them to an arithmetical screening, (sometimes highly complicated), select from the screenings some factor already well known, and then cry out, *Eureka!*

It may be well to state the fact, that such is the condition of the ruins even in the best preserved portions, that no *single* measurement is of any value whatever, and this, not in all cases from the injury to the parts from the effect of time and violence, but from carelessness or neglect in the original construction. For instance, the Kings chamber referred to above, is twice as long as wide, but no two measures either at the

bottom, middle, or at the top, coincide nor do any of the side angles measure precisely a right angle. All pyramid measures are *averages*, necessarily so, and from the *fiveness*, and other apparently controlling circumstances, the sides and ends of this chamber were *assumed* to have been intended as in the ratio of 16 to 5; from this, the working cubit, derived from the best attainable averages, is taken as 20.63 English inches; the width being 10 of these cubits and the length 20. The coffer in the middle of this chamber (an unmistakable sarcophagus) though of polished granite, is not truly wrought, and the latest and most reliable measurements of it made in 1882, required no less than 950 measurements inside and out, including 281 calliper measurements, and the resulting mean length outside was 89.62 inches, and width, 38.50 inches. Leaving the resulting capacity for future remark (for be it remembered, that this coffer is the grand standard heaven inspired, unit measure of capacity weight and length for the entire human family in the pyramidist's religion.) I proceded to introduce this probable width into the computation above quoted in lieu of 38.65. Then $38.5 \div 20.63 = 1.86$. Then $10^x = 1.86$ $\therefore x = 0.26951$. Ten times this is 2.6951. Where does the Napierian base of logarithms appear in this?

To return to the capacity of this coffer, Prof. Smyth, the present head-center of the Pyramid religion thus enunciates the process by which it may be derived from factors in Nature. "Multiply the tenth part of the cube of the ten millionth part of the earths Polar-axis (?) by the mean density of the earth (?) will equal the coffer capacity in cubic inches." To insure the result to which he aims, he takes the Polar-axis of the earth as 500,500,000 English inches, and the mean density of the earth at 5.7, and requires the computed capacity of the coffer to equal 71,464 English inches. The first two factors, it is needless to say are pure assumptions on his part, and the capacity thence derived is deficient by 500 cubic inches; the capacity by the later measurement being 71,960 cubit English inches!

It would seem that the claims for this coffer, being a standard for weights and measures, is not better sustained than is its claim to representing the base of our hyperbolic system of logarithms. We notice but one more of the happy discoveries of these enthusiasts.

The measure used by the builders (Noah or his Sons) was, according to Smyth, the sacred cubit of the Hebrews, and equalled 25.025 English inches (?), with this they laid off the base sides of the Pyramid equalling in number of cubits, the days and fraction of days of the tropical year, or 365.2422; this gives 9140.176 inches as the length of a side; not that such a length had ever been obtained by measurement, but this length was needed for his theory, and as the various actual measurements made in the years 1799, 1837, 1865, and 1869, ranged from 9,110 to 9,168 inches, he felt justified in assuming a little less than the mean; and it is significant in this connection, that Prof. Smyth lived for five months in a tomb on the spot, with every appliance for accurate measurement on hand, *yet he did not venture to measure the base himself at all.*

The later measurement of 1882 was conducted with all the accuracy attainable by modern instruments, and all conceivable checks interposed to insure accuracy in the result: the outside measurements being all by triangulation from a repeatedly measured base line. The operator, W. M. F. Petrie, lived on the spot from Dec. 1880, until April, 1882, and the result of his labors, published in detail, are accepted, by all men who are entitled to an opinion on such matters, as conclusive of the facts.

Petrie was originally a believer in the Pyramid theory, as was his father before him, but he was aiming to arrive at the truth in his labors here, regardless of any preconceived theory, and it is believed he attained it. He found the four sides of the base sensibly equal, the maximum difference beyond a mean, being but about an inch, and the mean of the four sides to be $9068.8 \pm .5$ inches.

This result dissipates the entire Pyramid theory into thin air. Any value to the base, less than 9,140 inches in length, is fatal to the theory of a Pyramid standard of weights and measures. The pronounced Pyramidist is however steeled against any such evidence of inaccuracy of measurement. They fall back upon the origin of their belief; and hold that fallible man, and his imperfect instruments, cannot hope to attain to the perfection of Infinite wisdom; and hence, they do not look for absolute truth in his measurements, but as suggested by St. Paul, "They walk by faith and not by sight."

J. W. ADAMS.

Trautwine's Civil Engineer's Pocket-Book.

1927 BROWN ST., PHILA., March 11th, 1885.

EDITOR ENGINEERING NEWS.—In your issue of 14th ult. you kindly printed my preface to the forthcoming edition of "The Civil Engineer's Pocket-Book."

I beg to say that since then that document has been revised to cover the following further changes of subject matter; correction and simplification of the remarks on counter-bracing; the substitution of a new table of endwise and sidewise crushing loads for timber based upon the last census, in place of the former table deduced from Hodgkinson's experiments; and corrections in transverse strengths of timber were necessary to agree with the more modern authority. In reference to the statement, "They are therefore believed to be correct," made in regard to the new tables of circles), the following foot-note has been added; "And as nearly accurate as their number of decimal places permits, except that if one be added to the final decimal of the circumferences and areas corresponding to the following diameters, (5 in number for circumferences, and 244 for areas, specified in the note) their error in excess will be a little less than their present error in deficiency. The greatest error in these is now *less than one in the final decimal.* It will then be *less than one-half*, as in all the others."

JOHN C. TRAUTWINE, JR.

Corbels.

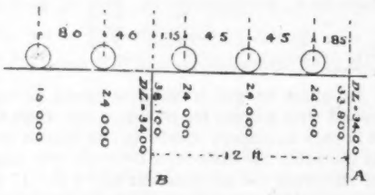
NEW HAVEN, March 2, 1885.

EDITOR ENGINEERING NEWS:—The question as to the efficacy of corbels in trestles, propounded by Mr. H. A. Young, in ENGINEERING NEWS of February 14th, is an interesting one, especially when the increasing scarcity and value of timber is considered.

The experience of the undersigned with timber trestles, both in construction and maintenance, has caused him to become an advocate of their use.

Stringers generally decay first and most rapidly at their ends, and they may be often seen sound in the body while ends and bearings are broomed and decayed; due, no doubt, to the churning action induced by the repeated application and removal of the loads, absorbing and expelling like a sponge the water which may have lodged near the joints. Corbels being continuous over the caps, their ends, where water is most readily absorbed, are protected, and decay does not proceed in them as rapidly as in abutting stringers.

That corbels practically reduce the span may be shown as follows: Consider a "consolidation" engine, having weights and wheel base as shown in the accompanying figure, moved from right to left over a space of twelve (12) feet, until the position as shown in the sketch is reached.



considering only the one span, the weight supported at $A = 33900 + 37300$ lbs. and at $B = 38100 + 3400 = 41500$ lbs. Now take, for example, a corbel at support B 14 inches wide and 8 inches deep, sized to 7 inches effective depth. The length of a beam fixed at one end and loaded at its extremity is

$$L = \frac{bd^2}{w} \times c.$$

Taking w as equal to the sum of the dead and live loads on the support B and the constant $c = 35$, the length of corbel, at the end of which the given load would be safely carried, will be

$$\frac{14 \times 49}{41500} \times 35 \times 2 = 1.155 \text{ ft.}$$

from which it is seen that the stringers might be decayed or burned off at the ends, one foot before the safety of the structure would be endangered, and they might also be proportioned for a span of 9.69 feet in place of 12 feet.

A. BRYSON,
Chf. Eng. H. & H. R. R.

Freezing of Water Pipes.

STILLWATER, WASHINGTON COUNTY, MINNESOTA.
March 10th 1885.

EDITOR ENGINEERING NEWS.—Dear Sir: It has been found by actual observation in the cities of Minneapolis, St. Paul, Stillwater and Duluth in the State of Minnesota, that water pipes which are placed below the surface of the earth usually in these cities from seven to eight feet do not freeze during the extreme cold weather in the winter, but during the month of March and usually during the first warm days or immediately following the first warm days, when the frost commences to come out of the surface of the ground, or the snow covering the earth is melting, that the waterpipes freeze in various localities. This is observable in each of these cities. The question naturally arising for solution is, why do the water pipes freeze after the warm weather has fairly commenced, and usually after the warm weather has continued from three to five days? We have taken some pains in trying to account for this unusual phenomenon, and we are at a loss to assign a satisfactory reason, although we can evolve many theories that would account for the same, each theory that we suggest seems open to some objection We therefore beg of you an explanation, feeling confident that you can solve the question for us.

FAYETTE MARSH.

(Will some one of our readers, who have investigated this matter more thoroughly than ourselves, answer the query of Mr. Marsh.)

Pile Driving.

DETROIT, LANSING & NORTHERN RAILROAD COMPANY.
IONIA, MICH., March 11th, 1885.

EDITOR ENGINEERING NEWS.—I would like to ask through the columns of the NEWS, if some engineer who has had charge of building pile bridges for railroads, will give the specifications for driving the piles, (those which were found by experience to be the best,) i. e.; weight of hammer, least or greatest fall required, the greatest amount of penetration allowed for the last blow of hammer with the given fall, etc., etc., and about the cost per pile for driving. Piles to be of oak and driven in a moderately firm soil.

M. V.

A paper on "Bearing Piles," read by Rudolph Hering before the Engineers' Club of Phila., in 1876, contains just the information inquired for. It was re-printed by this journal in pamphlet form.

ED. ENG. NEWS.

Chestnut St. Bridge Repairs, Philadelphia.

UNIVERSITY OF PENNSYLVANIA, PHILA., March 10th, 1885.

EDITOR ENGINEERING NEWS:—Your notes of the Chestnut Street Bridge in the ENGINEERING NEWS of 7 inst. leave room for further information and some explanations. You say "One party claims that the west river abutment has moved shoreward and the column struts were put in to arrest this movement."

This is a natural inference from the fact that these struts were so put in, but by reference to the proceedings of the meeting of the Engineer's Club, published in the same issue you will see that the engineer department of the city admits that the abutment pier has *not moved*; The drawings submitted also show that the resultant line of pressure, from the iron arch, intersects the grillage at a point situated about one-third of the breadth of base from the river or eastern edge and not as your article asserts, "very near the westward end of the timber grillage." Moreover this resultant pressure is opposed by that of the brick masonry arches on the west and it is only the difference of the horizontal components of these forces that tends to produce any sliding of this abutment. But the masonry is also "toed" into the grillage to prevent this "tendency," and it may safely be asserted that there has been no movement here. Your remarks as to the earth filling being the cause of the bulging and the wedging apart of the piles are directly to the point. The cause of failure in this case is very similar to that of the west approach to the South Street bridge, viz., the vertical sinking of the piles and consequent thrusting *forward* of the face of the unsupported masonry.

This masonry face has not *bulged* horizontally *toward* the retained material," as is stated in the record of proceedings. This would *increase* the span, but it has been pushed out into the non-resisting air space of the span, thus diminishing its original dimensions as shown in all the reports on the bridge, by nearly half a foot at the corners, thus giving it the appearance of having *bulged*.

The Review also says that "the riverward movement of the structure," is not evident, "because there seem to be no *cracks* or changes which clearly show this, etc. Possibly all engineers may not deduce the same conclusions from *cracks*, yet it is of importance that they should be able to make a correct diagnosis of them and understand their meaning. It has not I believe been clearly stated in any of the printed reports that there *is an old crack*, wide open, EIGHT INCHES at the surface of the ground, and *four inches* at 7 feet above, extending vertically up the rubble masonry of the south retaining wall at its junction with the eastern face of the heavy buttress, which stands about 25 feet to the rear of this abutment. Any one may readily insert his arm therein, full length. There are also numerous minor cracks on the soffit of the western arch, and its supporting wall, both vertical and oblique, which clearly show the direction of the movement and settlement.

Instead of these outward and visible signs being most abundant and most marked at or near the *abutment pier* and gradually diminishing towards the approach, as would be the case had the movement started at this pier, exactly the reverse obtains.

The only thing my transit points will show is that the abutment pier is not moving. A result which may be safely anticipated, and I believe, it is admitted by those who have inspected the bridge carefully that there has been no perceptible movement for some years. Then why these repairs? Respectfully yours,

LEWIS M. HAUPT,
Prof. of Civ. Eng.

Grade for Side Tracks.

NASHVILLE, CHATTANOOGA & ST. LOUIS R. R.
Office of Resident Engineer.
NASHVILLE, TENN., March 9, 1885.

EDITOR ENGINEERING NEWS.—In answer to an inquiry from Atlanta in your issue of February 28th, I would say that in constructing a gravity hoist I once had occasion to try some experiments as to the spontaneous movement of cars on grades. I found a great difference in the friction of cars owing to lubrication and flat wheels. As a general thing cars at rest will remain at rest on a seven-tenths grade. They will start without the application of any force but gravity on an eight tenths grade. Cars on a six-tenths grade if not in motion will remain so. Cars on less than five-tenths grade require a renewal of the impetus to keep them in motion. I refer to an average freight car on a straight track with 40,000 lbs. load.

Truly Yours,
HUNTER MCDONALD.
Ass't. Engr.

Will the Washington Monument Stand?

NEW YORK, March 17, 1885.

EDITOR ENGINEERING NEWS. An article in your last issue under the above heading, was sufficiently startling to lead to an examination of the plans of foundation, so far as they are accessible to us, and it is unquestionable that they are open to criticism. However satisfactory a concrete of 1 of cement, 2 of sand, 3 of pebbles, and 4 of broken stone, may prove when tested in a confined space to resist *crushing*, yet it must be regarded as an inferior material to withstand any tensile strain. It is not possible, that a proportion of 1 to 9 of cementing material to inert matter can result, under any known method of mixing, in enveloping the fragments, each and all, in the cementing material, which is a requisite for good concrete, as for cement mortar. That the new foundations of this monument, may, under the plan as shown on Page 169, be subjected to an undue tensile strain, by reason of leaving a mass of compressible earth (sand and clay) for such space within the foundation, is at least a possibility to be anticipated. To set at rest therefore all questions of this kind, one course is open, and but one occurs to me as probably efficient and that is, to sink a shaft in the center of the monument, through the rubble masonry to the underlying earth—remove the whole of this earth to the level of the bottom of the concrete on the side, and fill up the space of 45 feet square, with good concrete, and that there may be no danger in the process, make the frame work of the several driftways (sills, posts and beams) of iron and as the expense can be a matter of small moment, leave them as fixtures enveloped in the concrete, thus adding an element of bond to the concrete, which I think will silence all cavilers. A CIVIL ENGINEER.

City Surveying.

FOSTORIA, PA., March 9, 1885.

EDITOR ENGINEERING NEWS. Where a town has been laid out by a County Surveyor, with a two rod chain and a compass, and in after years other towns laid out in the same way are annexed, and a city is formed, and an accurate survey is wanted, and no accurate points of original survey can be found on the ground, and the measurements of the lots on the ground will not agree with the city maps, what would be the best way to proceed to make an accurate survey of the city, and to arrange the lots so there will be no dispute with the property owners? Yours truly,

W. W. H.

[The above questions apply to about every town or city in this country, or probably in any country where civilized customs prevail, in regard to real estate. There is no city without disputed boundary lines of lots, and in the settlement of these disputes lies the peculiar province of the Land Surveyor who is in himself judge, jury and advocate for both sides. Probably the worst case of extinction of monuments in this country was that of Chicago, after the great fire. The surveyors made a special study and analysis of each block in the burnt district, and "did the best they could" to reconcile any discrepancies. Comparatively few suits arose, thus demonstrating the good judgment and accurate methods of the surveyors. The only rule we know of is to locate undisputed points, accept monuments of long standing, and use the best evidences of documents and other attainable information and then divide up to the best of one's judgment, leaving the results for the adjudication of the courts if any parties claim to be wronged. Surplus and deficiencies as between actual measurements and recorded plats and deeds must be divided *pro rata* between *undisputed* or well established boundaries. Monuments must stand, no matter what the discrepancies.—ED. ENG. NEWS.

ENGINEERING NEWS three months for One Dollar.

Some Pittsburgh, Pa., Notes.

From our own Correspondent.

THE PROPOSED EAST END SEWER.

The ordinance to provide sewerage for that large and utterly unsewered district of the city of Pittsburgh, Pa., between Lawrenceville and East Liberty, failed to pass *second* reading, lately, in the Select Council by a tie vote. The ordinance contemplates the construction of a brick and stone sewer 15,142 feet, or nearly three miles in length. It is divided into three divisions, the first extending from the end of the present sewer at the intersection of Penn Avenue and 33rd street to Mathilda street, this part of the sewer being 8′ × 10′ in size; the second division is between Mathilda street and O'Hara street, the size of this portion being reduced to 6′ × 7′. The third divison is comprised between O'Hara street and the intersection of Penn Avenue and Beatty street, following generally the channel of Two Mile Run. This part of the sewer is to be circular, the internal diameter being six feet.

The city engineer's estimate of the cost is as follows:

6582 lin. ft. 8′ × 10′ sewer @	$25 =	164,550.00
4925 " " 6′ × 7′ " "	20 =	123,200.00
2400 " " 6′ " "	8 =	19,200.00
Engineering, Viewing, Advertising, etc.		15,347.50
Total cost		322,297.50

Notwithstanding the unfavorable action of Select Councils, it is confidently expected that the ordinance will be again called up at an early day, and then receive more favorable consideration, leading without doubt to its final passage.

The section to be benefitted is badly in need of a system of sewerage. It is fast building up, and the numerous cases of diptheria reported of late from that quarter show, the effects of a lack of means to carry off the offal and filth that indicates the worse that may be expected in case the remedy is not soon applied.

ALLEGHENY WATER SUPPLY.

Several statements having lately appeared in the public prints regarding the purity of the water supplied to the city of Allegheny, Pa., the superintendent of water-works of that city was a few days called upon for the facts in the case. In reply he said that the water in the Allegheny River was as pure as in any other river. The numerous freshets clear out the river, after which the water is pure. During the months of August and September the most complaints are made, and this is when the river is low; but in order to satisfy consumers it has been decided to have the water analyzed, and the result is anxiously awaited for.

PROPOSED NEW BRIDGE ACROSS THE OHIO.

There is a quiet movement on foot for the erection of a highway bridge over the Ohio River between that part of Allegheny locally known as Manchester and the West End of Pittsburgh.

The plans are as yet not fully matured, but it is proposed to have the bridge cross the river from the foot of Beaver Avenue to Main street, near the mouth of Saw Mill River. It will be a structure which, in beauty of design and solid strength, will compare favorably with any of the many bridges that the Smoky City can now boast of.

The location of the proposed bridge is in the bend of the river, on the banks of which most of the important mills and factories of Allegheny are situated.

At present, the means of communication are the ferry boats.

When the river is high, or filled with ice, they do not run, causing great inconvenience.

REPLACEMENT OF OLD WATER PIPES.

The superintendent of the Pittsburgh W. W. has just completed estimates for the replacing of the old and worn out water pipes under the principal streets of the old section of the city. These are to be submitted soon to the Water Committee.

The amount to be expended will foot up in the neighborhood of $50,000.

The estimate comprises pipe from 4 to 14 inches diameter, and the same are to be laid during the coming summer. They will enable the water department to give a better water pressure in the lower end of the city without causing the bursting of pipe, a most desirable end to business men, especially those who want water in the upper stories of buildings.

Public Buildings.

A correct statement of the amounts appropriated for the construction and repair of public buildings and the purchase of sites:

Baltimore	$227,000
Bangor	18,000
Boston	15,000
Brooklyn	135,000
Buffalo	37,500
Cairo Marine Hospital	27,000
Charleston, W. Va	1,153
Chicago (cleaning and painting the stonework and repairs to the custom house and the sub-treasury)	40,000
Cleveland	3,000
Columbus, Ohio	110,000
Harrisonburg, Va	22,500
Abingdon, Va	12,000
Lynchburg, Va	50,000
Concord, N. H	100,000
Council Bluffs	50,000
Dallas, Tex	25,000
Denver	28,000
Detroit	200,000
Des Moines	45,000
Dubuque	8,000
Frankfort, Ky	15,000
Fort Wayne	60,192
Galveston	47,500
Greensboro, N. C	7,500
Hannibal	55,500
Jackson, Tenn	10,000
Jefferson City	132,000
Kansas City	20,000
Marquette	50,000
Keokuk	100,000
St. Joseph, Mo	50,000
Louisville, Ky	200,000
Leavenworth	50,000
Macon, Ga	75,000
Montgomery, Ala	5,000
Minneapolis	110,000
New Orleans	15,000
Peoria	75,000
Poughkeepsie	30,000
Quincy, Ill	47,500
Reading, Pa	80,000
Richmond, Va	50,000
Rochester	80,000
Sacramento	100,000
St. Louis Marine Hospital	10,000
Shreveport	5,000
Syracuse	58,000
Terre Haute	75,000
Toledo	72,467
Troy	100,000
Tyler, Tex	50,000
Wichita	50,000
Fort Scott, Kans	50,000
Williamsport, Pa	25,000
Montpelier, Vt	75,000
Nebraska City, Neb	75,000
Wilmington, Del	150,000
New Albany, Ind	100,000
Manchester, N. H	100,000
Lexington, Ky	150,000
Springfield, Ohio	100,000
Winona, Minn	20,000
Jail at Sitka	4,000
Court room at Sitka	1,500
Court room at Wrangel	500
Court room and jail at Ounalaska	1,000
Court room and jail at Juneau City	4,000

LITERATURE.

The Designing of Ordinary Iron Highway Bridges, By J. A. L. WADDELL, C. E., Prof. of Civil Engineering in the University of Tokio, Japan. New York: John Wiley & Sons, 1885.

This valuable guide to bridge designing is an octavo volume of 244 pages, with 49 folded sheets of tables and illustrations. A portion of the text appeared during the last three years in the transactions of the engineering societies in the form of separate papers, but several portions of the book and many of the tables are new, and the whole presents a systematic discussion of iron bridge construction for country roads, manufacturing districts and city streets. The tables are so arranged that the labor of computation is reduced to a minimum, the exact sizes of joints, floorbeams, lateral bracing, lattice bars, etc., being given for all practical cases. The style of bridge discussed is the ordinary square panel Whipple truss of either single or double intersections, and the author remarks in justification of this selection that fully ninety per cent. of all the iron highway bridges in the United States are of that type. This fact alone, he says, ought to prove conclusively that they are the best type of bridge. The work is intended for engineers, students, and, to a certain extent, for county commissioners who purchase bridges. The chapter on specifications would certainly prove of value to commissioners, and if followed would result in a much better class of work than is usually found on county roads. Most of the book however

requires a preliminary knowledge of the strength of materials and of the theory of strains for its appreciative perusal.

The remarks of the author concerning the most economical number of spans for a given width of streams, and the most economical depth of truss are very excellent and would bear extension and amplification. His table of economic depths and panel lengths, deduced by figuring out diagrams of stresses and bills of materials for a number of different cases, is an interesting one, and leads to the conclusion that the ratio of economic depth to span is a variable one, ranging from about one-fifth for short spans to one-seventh for long spans. For a double intersection truss the conclusion is reached that the economic depth is about three feet greater than for a single-intersection truss of the same span and number of panels.

In regard to rivetting, Prof. Waddell makes a bold departure by omitting all consideration of the shearing stresses and proportioning the rivet for bending and bearing alone, since these are less than the shearing resistance. Full examples of the method of proportioning pins, floor beams and other details are given so that the student or designer may be able to check the dimensions stated in the tables. An example giving the method in detail for a span of 160 feet is carefully worked out in all its steps and concluded with the bills of material. The chapter on erection and maintenance, as also that on bridge lettings, is suggestive and instructive. The plates give full information in regard to the details of construction and arrangement, and among these we especially mention those by the author's pupils as being very creditably executed, and the working drawing for a timber false-work as being complete and likely to prove very useful.

In conclusion we strongly recommend this book to students and engineers desirious of learning the art of bridge design. The extensive practical experience of the author in the construction of highway bridges has led him to keep always in view economy as well as stability, so as to design a safe and durable structure at the minimum cost. Hence the results of his patient labor embodied in this book will be sure to prove of great value to the technical public.

THE HISTORY AND STATISTICS OF AMERICAN WATER-WORKS.

BY J. JAMES R. CROES, M. AM. SOC. C. E.; M. INST. C. E.

(CONTINUED FROM PAGE 157.)

DCCXXXI. IRVINGTON, N. Y.

Irvington, Westchester Co., N. Y., is on the hilly ground on the east bank of the Hudson River, 22 miles north of New York City. It was the home of Washington Irving, and is a favorite suburban place of residence. Water-works were built by the village in 1884, after plans of H. C. Pierson, C. E., the supply being taken from ground and surface water.

The principal source of supply is from a brook at a point 1½ miles distant from and 412 feet above the village, where an old pond has been excavated and enlarged, the bottom and sides being puddled and paved forming a storage, reservoir 300 feet long, 150 feet wide and 20 feet deep and having a capacity of 8,000,000 gallons. This supply can only be depended on for about six months in the year, and is supplemented by an artesian well 8 inches in diameter and 605 feet deep, yielding 26,000 gallons daily, from which the water is pumped by a Worthington duplex steam pump, having a capacity of 500,000 gallons to the reservoir.

Distribution is by 3½ miles of cast iron pipe with 25 fire-hydrants. The works having just been completed the number of taps and meters and the daily consumption cannot be given. Service pipes are of lead. The population in 1880 was 1,904. The works have cost $40,000 which is the amount of the bonded debt at 3½ per cent.

W. A. Burnham is President, and Adam Busch, Secretary of the board of Water Commissioners governing the works.

DCCXXXII. ITHACA, MICH.

Ithaca, Michigan, in lat. 43° 15′ long. N., 84° 30′ W. the county seat of Gratiot Co., is in a fine agricultural region.

Water-Works were built in 1878 by the city, after plans of Wm. H. Burnham taking the supply from an Artesian well 4 inches in diameter and 250 feet deep. The water is pumped by a single-acting deep well pump of 2½ inch bore and 12 inch stroke, driven by a wind-mill 18 feet in diameter, made by the U. S. Wind Engine & Pump Co., to a wooden tank 20 feet in diameter and 14 feet high, set on a timber trestle 30 feet in height. The distribution is by 4 inch cast iron pipe. The cost of the works has been about $2,500. The population in 1880 was 600. No further information can be obtained.

WATER.

FOND DU LAC, Wis., is asking for plans and estimates for water-works.

ABENDROTH & Co., of New York, have filed a bond for the completion of the East St. Louis water-works.

A $35,000 system of water-works is contemplated by the enterprising town of Eliott, in Cass County, Iowa.

ANOTHER artesian well is to be attempted at Live Oak, Florida.

GRAND ISLAND, Wis., is moving for the erection of water-works.

CLEVELAND, Ohio, has decided to lower all the water mains where most trouble is experienced from frozen pipes.

THE North Carolina Legislature has passed to third reading the bill to incorporate the Greensboro Water Supply Co.

THE well at Choctaw, Ala., recently reached a depth of 1,345 feet, since which time the water has been gushing out to a height of 64 feet above the derrick floor.

THE local consumption of water in Duluth, is growing. During February 12,365,000 gallons were pumped, a daily average of 441,620 gallons. About 10,960,000 gallons were pumped in January and 7,300,000 in December.

THE citizens of Swainsboro, Georgia, offered to pay half the cost of sinking an artesian well if the county would pay the other half. This the county refused to do.

THE Ohio Legislature, on March 13th, passed a bill authorizing Clyde, Sandusky County, to issue bonds for an extension of its water-works. And also passed a bill giving same power to the town of Massillon.

ALLIANCE, Ohio, has ratified the contract entered into between the Alliance Water Co., and the village as authorized by an ordinance passed Jan. 5th, 1885. The works are already built, and the vote was to accept the contract.

LAKE CITY, Florida, is agitating the question of a water supply. The County Commissioners have appropriated one-third of the amount necessary to erect water-works, lay pipes, etc., and the city fathers have added a generous amount to the sum, and the city will soon have water.

SEVERAL thousand acres of desert land in Shasta County, Cal., situated about twenty miles east of the C. & O. railroad, a portion of it lying on the McCloud river, has recently been filed on by parties residing in Shasta County, Colusa, and San Francisco. The whole tract is susceptible to irrigation, and several parties have inaugurated a big scheme to irrigate 60,000 acres with water taken from the head of the McCloud river.

DAYTON, Ohio, March 40.—The water-works bonds of this city, amounting to $505,000, were to-day sold to Blake Bros. & Co., of Boston, at a premium of $2 60 on $1,000. There were a number of bidders, among them them Spitzer & Co., of Toledo, and Albert Netter, of Cincinnati. The bonds bear 4 per cent. interest, and are issued for twenty years, the interest payable semi-annually. The bids were varied, ranging from a demand of $55,000 to place them at 5 per cent. to the above premium.

W. S. KUHN, water-works contractor, and associates will start work April 15, on the Muncie, Ind., Water-works. The pipe line consists of seven miles cast-iron pipe, for which the Cincinnati and Newport Iron & Pipe Co., have the contract, and the hydrants and valves will be supplied by the Ludlow Valve Co. The pumps are not contracted for.

The same parties built the Connellsville, Pa., Wellsville, N. Y., Hornellsville, N. Y., Sioux Falls, Dakota water-works, and still operate them.

THE following bids were opened on the 12th by the Philadelphia Gas Works—for 1,460 length of 20" cast-iron pipe weighing 165 lbs., per foot and the necessary special castings.

	20" Pipe per foot.	Special Castings per pound.
A. H. McNeal, Burlington, New Jersey	$2.$\frac{25}{100}$	2¾c.
Camden Iron Works Camden New Jersey	$2.$\frac{75}{100}$	2¾c.
Gloucester Iron Works Philadelphia	$1.$\frac{75}{100}$	1¾c.
Meilert & Co. Reading, Pa	$1.$\frac{95}{100}$	2¾c.

Awarded to Gloucester Iron Works.

THE Vicksburg, Miss., Water Works Company has been organized to build water works at once in that city, which will cost about $350,000. James S. Pierson, of Brooklyn, N. Y., is President, and Walter P. Elliott, of New York, Secretary.

NEWS OF THE WEEK.

Contracting.

Street and Sewer Work.—Lowell, Mass., has voted to create a ten-year loan of $100,000 for street and sewer work.

A New Stock Exchange, costing about $60,000, is projected for South Omaha this summer.

Vicksburg Tunnel.—The Louisville, New Orleans & Texas Railroad is constructing a tunnel just below the city of Vicksburg. It is a difficult job.

New Bridges.—The Board of Commissioners at Shelbyville, Ind., lately decided to put up three new bridges in different parts of that country.

Piles and Lumber.—The new lighthouse dock at Key West will require 600 creosoted piles and 300,000 feet of lumber.

Roads.—Madison county, Ala., has determined to build one hundred and twenty-five miles of macadamized roads.

New Depot.—The Cincinnati, Washington and Baltimore Company has broken ground for extensive improvements to its passenger depot at Chillicothe.

Granite for Limestone.—The Texas Legislation has before it a bill to substitute granite for limestone, at least in the front wall of the New Capitol. The increased expense is estimated at $700,000.

A Hole Under the City.—A large portion of the square being graded for the new Court-house in Nashville, Tenn., caved in on March 11th, revealing a deep cavern under the city, several hundred feet in length.

A Levy of Money for Reclaiming Wet Lands.—BLOOMINGTON, March 13.—The drainage commissioners of the Mason and Tazewell district, made another levy of $115,000, making a total of $230,000 levied for this great undertaking, which will reclaim between 50,000 and 100,000 acres of land.

Draining Sunken Lands.—The Governor of Arkansas has recommended a joint survey with Missouri of the sunken lands in South East Missouri and North East Arkansas. About 4,000,000 acres of land are there subject to overflow from the St. Francois, White Water, Carter and Black Rivers, and can be made valuable. The survey is estimated to cost each State about $10,000.

Georgia Marble.—The Atlanta *Constitution* says the north Georgia marble is the finest in the world. A local quarryman has just cut a counter for the Kimball House sixteen feet in length and four feet broad out of one solid block. He says: We "could supply a flawless marble column eighty feet long and five feet in diameter. A hundred years from today the quarries will have been barely touched. The supply of marble of surpassing quality and of every shade of color is exhaustless."

Railroads, Bridges and Canals.

Bridge Rebuilt.—The railway bridge over the Mississippi river at Clinton, after fourteen years service, is being replaced with new iron spans.

The Nashville Tenn., Bridge.—The contract for building the bridge at Nashville, Tenn., has been awarded to the Louisville Bridge Co. for $90,000. The Morse Bridge Co. bid $92,500.

Tubular Rails, have been rolled at La Grange, Mo. They are claimed to be new in design and to be practically continuous, with a wearing surface of steel readily renewed.

Work Stopped at Coal Harbor, B. C.—Orders have been received for the Canadian Pacific Railway to stop all work of surveying at Coal Harbor, B. C. The engineering staff has been discharged. Coal Harbor had been selected as the Pacific coast terminus of the Canadian Pacific, but the change from Port Moody was not considered satisfactory to the Dominion Government

A Belt Line Around Chattanooga.—CHATTANOOGA, March 18.—The last spike was driven to-day on the Union Railway, a track of steel rails completely encircling the city and putting a million dollars worth of property on the market and connecting with every railway coming into the city. It is one of the largest private enterprises ever undertaken in the South.

The St. Petersburg Ship Canal, has been completed, and ships of large tonnage can sail direct to the port of St. Petersburgh, without, as heretofore, undergoing transhipment of goods at Cronstadt. The Canal, which is 26¼ versts in length (1 verst = 5⅛ furlongs), runs from the Island of Goutouiew, in the Neva, to the Cronstadt roads, and has an average depth of 22 feet, and a portion of the Neva has also been dredged to the same depth.

Table of Prices New Croton Aqueduct.

ITEMS.	PRICES OF BROWN, HOWARD & CO.		PRICES OF O'BRIEN & CLARK.				PRICES OF HERMAN CLARK.	
	SEC. 2	SEC. 3	SEC. 4	SEC. 5	SEC. 6	SEC. 7	SEC. 8	SEC. 9	SEC. A.	SEC. B.
a Rock excav. in open trench per c. y			$2 00	$2 50	$1 75	$1 75	$1 75	$2 00	$1 75	$1 75
b Earth excav. in open trench per c. y			90	1 75	80	80	80	80	50	50
c Soiling per c. y	75	75	75	75	40	40	40	40	50	50
d Tunnel excav. per c. y	$7 00	$6 50	6 40	6 25	7 00	7 00	7 00	6 75	7 00	7 50
e Large shaft excav. per lin. ft	120 00	100 00	100 00	100 00	150 00	150 00	150 00	150 00	150 00	150 00
f Small shaft excav. per lin. ft	80 00			90 00	140 00	140 00	140 00	140 00		140 00
g Brick masonry per c. y	11 00	10 00	11 00	11 00	10 00	10 00	10 00	10 00	10 00	10 00
h Concrete masonry 5 parts stone 1 part cement per c. y	5 75	5 75	5 00	5 50	5 00	5 00	5 00	5 00	5 00	5 00
i Concrete masonry 3 parts stone 1 part cement per c. y	6 75	6 75	6 00	6 50	5 50	5 50	5 50	5 25	5 50	5 50
j Rubble stone masonry per c. y	5 00	5 00	6 00	5 50	5 00	5 00	5 00	5 00	5 00	5 00
k Face work for rubble stone per sq. ft			20			80		80	40 00	40 00
l Dry stonemasonry and paving per c. y			7 50			2 00		2 00		
m Rectangular paving per c. y			15 00			2 50		2 50		
n Cut stone masonry per c. y	60 00	60 00	50 00	60 00	40 00	40 00	40 00	35 00		
o Rough pointed face for cut stone masonry per sq. ft			25			80		80		
p Fine Hammered face (six cut) for cut stone per sq. ft			75			90		90		
q Timber placed and fastened B. M. per M			50 00	50 00	30 00	30 00	30 00	30 00		
r Piles driven and prepared per lin. ft			50	50	25	25	25	25	40	40
s Additional for all kinds of masonry laid in Portland cement mortar per c. y	2 50	2 50	2 50	2 50	1 50	1 50	1 00	1 50	1 50	1 50
t Additional for all kinds of masonry laid in American cement mortar 1 to 1 per c. y	1 00	1 00	1 00	1 00	1 25	1 25	1 25	1 50	30	30
u Shaft filling per c. y	1 00	80	75	75	40	40	40	40	40	40
v Drain excav. per c. y	1 00	1 00	1 00	1 00	1 00	1 00	1 00	1 00	65	65
w Tile drain six inch per lin. ft	30	30	30	30	30	30	30	40	90	90
x Tile drain eight inch per lin. ft	45	45	45	45	40	40	40	65		
y Tile drain ten inch per lin. ft	60	60	60	60	65	65	65	90		
z Tile drain twelve inch per lin. ft	70	70	70	70	90	90	90	90		
aa Tile drain fifteen inch per lin. ft	1 15	1 15	1 15	1 15	1 25	1 25	1 25	1 25		
bb Tile drain eighteen inch per lin. ft	1 25	1 25	1 25	1 25	1 50	1 50	1 50	1 50		
cc Borrowed earth per c. y			50					40		

N. C. Railroads.—The following bills are before the North Carolina Legislation, to incorporate the Wilmington and the Onslow & E. Carolina R. R., and the Pittsboro R. R.

Shorter Time to Chicago.—CHICAGO, March 17.—The Lake Shore and New York Central Railroads have arranged for an expedited service between Chicago and New York, to go into effect when the Spring schedule is arranged. The time from New York to Chicago will be about an hour shorter than at present, and that from Chicago to New York about two hours shorter.

The San Joaquin and Sierra Nevada Railway is steadily pursuing its way through Calaveras County, Cal. The grading and bridge work between Burson the present terminus, and Valley Springs has been completed, and a train-load of ties forwarded for immediate use. Railroad iron has been purchased for this section of the line and been shipped to Burson.

The Severn Tunnel.—The construction of the Severn Tunnel Railway continues to progress satisfactorily. The length of permanent tunnel now completed is 6,950 yards out of the total length of 7,664 yards, and a further length of 550 yards has been arched. A considerable portion of the line is ballasted, and the laying of the permanent way has been commenced.

A New Way to the South.—WASHINGTON, March 18.—A new passenger route between Washington and the South and South West will be opened by the Shenandoah Valley and Norfolk and Western Railroads and their connections, on Monday, by securing a special train over the Baltimore and Ohio Road via Shenandoah Junction, sixty-one miles West of Washington.

Indianapolis Links.—INDIANAPOLIS, March 11.—The Dayton and Ironton Road, 155 miles in length, running from Dayton to the Ohio River, and forming a heavy feeder and important ally of the Indiana, Bloomington and Western, is to be converted into a standard gauge. The company will expend $1,700,000 in making it the best road in the country. Bridges are being rebuilt standard width, new ties and steel rails laid, and every thing prepared to convert the gauge in a few hours when the new material is all in.

Railway Extension in Jamaica, W. I.—On the 26th of February the extension to Porus of the Jamaica Government Railway was opened by His Excellency the Governor, Sir Henry Wylie Norman. Regular trains began running on the 2nd of March. This extension is of 23 miles, and was built by Messrs. Reid & Mackay, of London, at a cost of $1,010,000, or 5¼ per cent. above the original estimates. Another branch of 16 miles to Ewarton is being built up by the same firm, and will be completed very shortly. Valentine Bell, M. I. C. E., is Chief Resident Engineer. The existing lines last year paid 7¼ per cent.

A New Road to Chautuaqua.—CORRY, March 8.—A company has been formed at Warren to build a narrow gauge railroad from Warren, via Sugar Grove, intersecting the New York, Pennsylvania and Ohio Railroad at Ashville, and thence to Maryville, N. Y., and it will probably be extended entirely around Lake Chautauqua. A charter has been obtained in this State, but none in New York State yet. The officers of the company are: President, George P. Orr; vice-president, A. J. Davis; treasurer, Frederick Morck, and G. C. Hamilton, engineer.

A New Southern Road.—PENSACOLA, Fla., March 15.—Charters have been granted to build a railroad from Pensacola to Memphis, which, when finished, will give the North and Northwest the shortest, best and most direct outlet to the gulf, Pensacola, with its deep water harbor, holding the key to the South by way of the gulf.

A Railroad Purchased.—The Southern Pensylvania branch of the Cumberland Valley Railroad has finally been merged into the Pennsylvania Railroad system. A suit was begun some time ago by Peter McTague, a first mortgage bond-holder of the road, in the United States Circuit Court, but this was discontinued on Wednesday, on motion of James Fort, the counsel, because the Cumberland Valley Company purchased the entire mortgage, principal and interest, amounting to $1,000,000.

The Southern Pennsylvania branch must not be confounded with the Vanderbilt road, the South Pennsylvania, running to Pittsburg. The former road is but a branch, twenty-eight and a half miles in length, and running from Richmond, Pa., to Chambersburg Junction, where it connects with the main line of the Cumberland Valley. The franchises of the road also include about 20,000 acres of valuable iron lands.

Bridging the Arkansaw.—The St. Louis and San Francisco Road has let the contract for a new bridge over the Arkansas River at Van Buren, on the Arkansas Division. The bridge will be of iron, with three fixed spans of 256 feet each, four fixed spans of 165 feet each, and one draw span of 370 feet. The total length of the bridge will be 1,798feet. The piers in the river channel will be sunk to bed-rock, by Wm. Sooy Smith & Son, by the pneumatic process employed in the construction of the St. Louis bridge. The contract has been awarded the Union Bridge Company, of New York, and 200 men are already at work under the supervision of the Frisco's chief engineer, Jas. Dunn. The structure is to be completed by November 1. The total cost is estimated at about $400,000.

A Kansas Road.—TOPEKA, KAN., March 5.—The Ellsworth, Great Bend and Western Railway Company, was chartered by the Secretary of State to-day. This company proposes to build, operate and maintain a line of railroad of standard gauge, between Ellsworth in Ellsworth County, Kan., and Pueblo, Col., running through the Counties of Ellsworth, Barton, Rush, Ness, Lane, Scott, Wichita and Greely in Kansas, and thence in Colorado to Pueblo, a distance of about 470 miles; and between Great Bend, in Barton County, and El Paso, Tex., running through the Counties of Barton, Stafford, Pratt, Comanche and Ford, in the State of Kansas, to El Paso, Tex., a distance of about 560 miles. The places of business shall be at Great Bend and Ellsworth, and it may also transact business at Pueblo and El Paso. The capital stock is placed at $5,000,000. The directors are: G. F. Moses, A. Y. McCormick, C. Samuels, J. C. Gwinn, Charles Chamberlain, David Roberts, E. W. Moses and James Clayton, of Great Bend, and S. Jackson, G. B. Peale and D. B. Long, of Ellsworth.

Miscellaneous.

A Proposed Ship Railway.—It is proposed to build a ship railway across the seventeen-mile neck of land lying between the Gulf of St. Lawrence and the Bay of Fundy. It would save a voyage of 600 miles around a dangerous coast. The Canadian Government, in 1882, granted a subsidy of $30,000 annually for twenty-five years when completed. This Chignecto Railway, as it is called, is finally decided upon. The road will have four tracks, over a practically level country, and will transport ships of 1000 tons only. The capital stock is $3,250,000. The detail of the plan is similar to the Eads Ship Railway.

Trying Horseshoes on Sewer Gas.—"In these times I will take no chances," said a Jefferson street resident of Brooklyn, the other day, as he arrived home with a half dozen old horseshoes. "You can't trust science in plumbing. There's too much diphtheria and sewer gas around to take any chances on this business with children in the house."

"What are you going to do?" asked his wife.

"Do? Don't you see? Look here—these horseshoes. I am going to hang one of these on every wash basin trap in the house. There is nothing like caution."

An Enormous Spool.—The wire rope for the St Louis cable road will be seven or eight miles in length, the largest ever made in this country, and will be reeled or wound on one immense spool. As it weighs 87,500 pounds, a special truck will be used for its transportation, and the same one will be needed that carried a cable of 86,650 pounds weight from Trenton to Jersey City. It is not known whether the immense spool can pass through St. Louis tunnel, and the agent at Trenton has been instructed to obtain its dimensions.

Telegraphing From the Limited Express.—The Pennsylvania people have introduced a new and very accommodating feature on their limited express trains. The conductor of each of the limited trains is supplied with a large package of envelopes. They were invented by an employe of the company, and are weighted with lead so that they may be tossed from a moving train to a station agent by passengers who wish to forward telegrams before the train reaches its next stopping place. On the envelope are printed directions for the telegraph operator to forward the dispatch at once.

Pneumatic Tubes Between London and Paris.—It is proposed that two pneumatic tubes be laid, following the line of the northern railway from Paris to Calais, thence across the channel to Dover, and following the line of the Southeastern railway to London. Letters could be thus transmitted between the two capitals in one hour. Wagonettes like those now used to transport telegrams from Paris are to be used, weighing ten kilogrammes, and capable of carrying five kilogrammes weight of mail matters. Twenty pneumatic trains are to be started every hour. The cost is estimated to be $7,000,000. The total distance is 475 kilometers.

An Ancient Pavement.—The quadrangle of the Royal Exchange, London, after having been open to the sky for 300 years and more, is now roofed in. The old rough tessellation in lozenge-shaped divisions throughout the area is composed of small blocks of Turkey stone, and though a little uneven, and weather-worn, is not unpleasing to the eye. It claims the sympathy of the merchants as being the original pavement on which Sir Thomas Gresham walked daily, and on which Queen Elizabeth stood when, on the 23rd of January, 1571, her herald declared "The Royal Exchange" henceforth open for the use of the citizens of London. It has survived two exchanges destroyed by fire, and has certainly acquired a certain degree of historical interest.—*Boston Herald.*

Skating Rink Floors are kept in good conditions, in Cleveland, O., by revolving a grindstone, fitted between shafts, over the surface. The finer work is then done by pumice stone.

New Hopper Dredges.—The well-known firm of Messrs. Simons & Co., of Renfrew, Scotland, have built two new hopper dredges for the Harbor Commissioners of Belfast, Ireland. They may be described as bowwell twin-screw hopper dredges, each capable of collecting 800 tons of spoil, and afterwards of carrying it out to sea. Of course they are built so as to be able to load scows with the spoil, in order that it may be utilized in filling up slob land. Each dredge will be some 185 feet in length and 38 feet in breadth, and be capable of lifting 400 tons of mud, sand, clay, &c., per hour, and also of dredging to a depth of 35 feet below water level. They will each have two steam engines, the combined indicated horse-power of which will be 500. After these dredges have collected a cargo of 800 tons they will be able to carry out to sea their full cargo at the rate of some nine knots per hour. There will be suitable accommodation for the crews, and they will be supplied with all the newest appliances for the purpose for which they are being built. Winches, buckets, hoisting apparatus, and, indeed, the gearing of every kind will be of the most approved pattern. All the latest patents in connection with this particular class of vessel, and especially in connection with the mechanical appliances with which they are equipped, are being adopted. The reputation which the firm has acquired for the construction of dredging plant generally, and especially for the building of this particular kind of dredge, is a sufficient guarantee that the craft will be turned out in the most complete manner. These hopper dredges will, it is expected, be finished in August next.

Index to Periodical Literature.

African Inland Sea. *An Inland Sea for Africa.* The existing physical features of the site for the proposed inland sea, and the changes which will probably take place after its completion, with the advantages to be derived therefrom. The engineering features are barely touched upon. From All the Year Round. *Littell's Living Age*, Dec. 24, 1884, pp. 818 to 822.

African Inland Sea. *La Mer Interieure Africaine*; a pamphlet of great ability and completeness, describing the nature of the difficulties to be overcome, and the engineering details of the project, with maps. By Le Commandant Roudaire. Pub. by La Soc. Anonyme des Pub. Pinodiques. 13-15 quai Voltaire, Paris.

Bridge, *see* Girders.

Bridge, Blaauw Krauts. *The Blaauw Krautz Viaduct in Cape Colony.* The center span is a trussed arch of 220' span and 90' height. The reasons for selecting this design are briefly stated. Illustrated with two views taken from photographs. *Engineer*, Feb. 27, 1885, pp. 159 and 165.

Bridge, Forth. *The Forth Bridge.* A full page engraving prepared from a photograph (taken July 25, 1884) of the masonry and caisson of the North Eastern column in the main pier on the Inchgarvie. *Engineer*, Feb. 27, 1885, p. 168.

Bridge, Forth. *The Forth Bridge.* A perspective view of the air lock used in the 70 feet caissons, with description. The doors are interlocked and are worked by hydraulic machinery. *Engineer*, Feb. 13, 1885, pp. 128 and 134.

Cable Railway; Motive Power. *The Motive Power of the Philadelphia Cable Railway.* An illustrated description of the engines, gearing, drums, cable connections, tension-pulley, grip, &c., with the method of operating. *Scientific American*, Feb. 21, 1885, pp. 111 and 117.

Cofferdam, Floating. *A Floating Cofferdam.* Illustrated description of a sectional floating cofferdam, made of timber, in two halves for convenience of transporting it and passing it through locks. It contains water-tight chambers by means of which it can be floated and easily adjusted in location. The method of using it in the removal of obstructions in river channels, and also its adaptability to pier foundations are described. By Edwin F. Smith *Proc. Eng. Club of Phil.*, Nov., 1884, pp. 240 to 242.

Cofferdam, Floating. *The Means Employed in Repairing Belmont Submerged Main at Philadelphia.* A damaged main in the bed of the Schuylkill River was repaired by means of a balanced floating cofferdam, which is fully described and clearly illustrated in this paper. By J. J. de Kinder. *Proc. Eng. Club of Phil.*, Nov. 1884, pp. 232 to 237.

Docks, London. *Etudes sur la Construction et l'Aménagement des Ports de Commerce.* A description, with many illustrations, of the Prince Albert docks, London. *Les Annales des Travaux Publics*, Feb. 1885, pp. 1286, 1287.

Dynamos. *Driving Dynamos.* Illustrated description of several systems of driving dynamos devised by Mather & Platts of Manchester, (Eng.) *Engineering*, Feb. 13, 1885, pp. 156 and 159.

Electric Lighting. *The power expended in Electric Lighting.* An analysis of the power expended for driving a dynamo, showing the losses and the actual effective output of the power applied, for various dynamos, and under differing conditions. By Gilbert Kapp. *Engineer*, Feb. 27, 1885, pp. 159, 160.

Girders, Calculations.—*Simple Methods of Calculating Stresses in Girders No. II. Bow String Girders.* A new method of obtaining definite formulæ free from any assumed conditions as to the course taken by the stresses. Illustrated with a page of diagram stresses for every position of live load. By Chas. Lean, M. Inst. C. E. *Engineer*, Feb. 20th, 1885, pp. 139, 140.

Jetties South Pass.—*The South Pass Jetties. Ten Years' Practical Teachings in River and Harbor Hydraulics.* The works are briefly described, the results more fully, and the general lessons in greater detail. By E. L. Corthell. *Trans A.M. Soc. Civil Engineers*, Oct., 1884, pp. 313 to 330.

Levees.—*Levee Theory Tested by Facts.* The theory of confining the flood volume of a river within its channel by levees is combatted, and the proposition that engineering effort, so far as it may affect volume, should be in the direction of equalization is maintained, and supported by many facts and figures. By Robert E. McMath. *Trans. Am. Soc. Civil Engineers*, Oct. 1884, pp. 331 to 358.

Petroleum Storage.—*Storage of Petroleum.* The method adopted by Ingall, Phillips & Co., at their large establishment on the Thames. The oil is received in barrels, transferred to a central point on rails by gravity, weighed, raised to an upper flow by an automatic elevator, emptied into tanks by a simple device, and run into a large receiving tank, and thence delivered as required. A very interesting account. *Engineering*, Feb. 15, 1885, p. 168.

Railroad Telegraphing. *Phelps Induction Telegraph* Descriptive with illustrations of the Phelps' method of telegraphing from moving trains, including the cost per mile as constructed and in operation on a 12-miles section of the N. Y., N. H. & H. R. R. *R. R. Gazette*, Feb. 20th, 1885, pp. 114,125.

Railroad Terminals. *Terminal Facilities of the Pennsylvania Railroad at New York.* A description of the terminal yards in New Jersey, and of the method of operation of the yard, elevator, piers, transfer bridges, &c. Fully illustrated. By Gratz Mordecai. *R. R. Gazette*, Feb. 20, 1885, pp. 113,114.

Railroad Track. *Oscillation from Broken Joints.* A discussion of the effect of laying tracks with broken joints, in which the conclusions are favorable to that method. *R. R. Gazette*, Feb. 20, 1885, p. 118.

Railroad Track Repairs. *Management of Forces engaged in Railway Track Repairs.* Suggestions on the selection of foremen, organization of gangs, method of doing the work, and forms of reports. By Benjamin Reece. *Trans. Am. So. Civil Engineers*, Nov. 1884, pp. 396 to 408.

Market Report of Engineering Materials.

New York, March 19, 1885.

NOTE.—The following Market Report gives wholesale prices on the New York Market unless otherwise stated. It is intended as a general guide to the estimating engineer, and both the range of material and the market location will be extended as rapidly as possible. We give it with this caution, that, as is well understood in business transactions, the amount of bill, distance from market centre and conditions of payment will have a material influence on the final paying prices.

IRON.

STRUCTURAL IRON.			
Angles		2.2c.	@ 2.6c.
Tee		2.8c.	@ 3c.
Beams and channels		3.0c.	@ 3.5c.
Tank		2c.	@ 2.1c.
Shell		2¼c.	
Steel plates, Tank		3c.	@ 3¼c.
WROUGHT-IRON PIPE.. PITTSBURGH.			
Butt welded, black	Discount	47½	
" " galvanized	"	40	
Lap welded black	"	65	@ 67½
" Galvanized	"	47½	@ 50
Boiler tubes	"	60	
RAILS.			
Steel (large lots at mill)		$26	@ 27.5
Old rails		16.75	@ 17.50
Old rails, steel		16	@ 17
R. R. spikes			2c
R. R. splice-plates		1.65c.	@ 1.75c.
R. R. Track Bolts		2.35c.	@ 2.65c.
Barb-wire fencing, galvanized		4¼c.	@ 5¼c.
" " painted		3¼c.	@ 4¼c.
Corrugated iron			
Nails			
Iron		2.25	
Steel		2.35	

METALS.

COPPER.		
Lake Superior	11	@ .11¼
Other Brands	10¾	@ 10¾
LEAD.		
Com. Domestic	3.60	@ 3.70
Lead Pipe	.05¾	
Tin-Lined Lead Pipe	.15	
Sheet Lead	.06¾	
ZINC.		
Sheet	5.15	@ 5.25

BRICK.

(Cargoes afloat)		
Haverstraw 1st per M.	$6.00	@ 6.25
" 2nd "	5.62	@ 5.87
Fishkill	4.75	@ 5.50
Up-River		
Jerseys	5.25	@
Long Island		
" pale		
FRONTS.		
Croton red	14.00	@
" dark	14.00	@
" brown	12.00	@
Philadelphia pressed	22.50	@ 23.00
Trenton "	22.50	@ 23.00
Baltimore "	37.00	@ 41.00
Buff "	33.00	@ 35.00
Enameled English	65.00	@ 130.00
" American	85.00	@ 120.00
Fire brick	25.00	@ 40.00

CEMENT.

PORTLAND.		
Robins & Co., Extra English 425 lbs. per bbl.	2.75	@ 2.80
K. B. & S. English 400 lbs	2.85	@ 3.00
Burham " "	2.70	@ 2.85
Rochester Castle " "	2.50	@ 2.60
J. B. White & Bro. " "	2.50	@ 2.60
Other brands, " "	2.40	@ 2.50
Keene's fine " "	9.50	@ 9.75
" course " "	5.25	@ 5.50
Roman	2.75	@ 3.50
Dyckerhoff, German 400 lbs	2.60	@ 2.65
Star, " "	2.60	@ 2.65
Alsen, " "	2.55	@ 2.60
Hanover " "	2.40	@ 2.50
Other brands, " "	2.35	@ 2.40
Saylor's American	2.15	@ 2.50
F. O. Norton	1.10	
Rosendale cements	0.90	@ 1.00

LIME.

Rockland common per bbl	1.00	
" finishing	1.20	
Glensfalls, common	.85	
" finishing	1.05	@ 1.10
Kingston, ground	0.95	

STONE.

Cargo rates at New York.

Amherst freestone, No. 1 per cub. ft.	0.90	@ 95
" " No. 2 "	0.75	@ 0.80
" " light drab "	0.80	@ 0.95
Berlin " in rough "	0.75	@ 1.00
Berea " "	0.75	@ 1.00
Brownstone, Portland, Ct. "	1.00	@ 1.30
" Belleville, N. J. "	0.75	@ 1.25
Granite, rough	0.60	@ 1.25
Common building stone per load	2.00	@ 3.00
Base stone, from 2½ to 6 ft. lengths, per lin. ft.	0.40	@ 3.00

SLATE.

Purple roofing per square	6.00	@ 7.00
Green "	6.00	@ 7.00
Red "	15.00	
Black Penna. (at New York) "	4.50	@ 5.00

LUMBER.

PINE, Common box per M.	18.00	@ 20.00
" Good "		
Tally plank, 1¼ in each.	.44	@ .50
Tally boards, dressed "	.28	@ .30
SPRUCE, Boards dressed "	.25	@ .28
Plank, 1¼ in "	.28	@ .30
" 2 in. "	.38	@ .40
" 2 in. dressed "	.43	@ .45
Timber per M.	20.00	@ 22.00
HEMLOCK, Boards each.	.18	@ .20
Joist, 2¼ × 4 to 4 × 6 in	.17	@ .44
OAK per M.	55.00	@ 65.00
CYPRESS 1, 1¼, 2 and 2¼ in "	35.00	@ 40.00
YELLOW PINE, Girders "	26.00	@ 35.00
Dressed flooring "	30.00	@ 40.00
SHINGLES, Extra shaved pine, 18in. "	4.50	@ 5.00
" sawed 18 in. "	2.50	@ 2.60
LATH, Cargo rate "		

PAINT.

Lead, white, American dry per lb	.04¾ @ .05
" " in oil pure "	.05½ @ .05¾
English, B. B. in oil "	.08½ @ .08¾
Red, American "	.05½ @ .05¾
Litharge "	.05 @ .05½
Venetian red, American "	.01 @ .01¼
Indian red "	.05 @ .10
Vermillion, American lead "	.11 @ .11¼
Paris green "	.15 @ .19
Umber, Amer. raw and powdered per lb.	.01¼ @ .01½
Drop black, Amer. "	.08 @ .12
" " "	.09 @ .11½
Chrome green "	.05 @ .15
Oxide zinc, American "	.03¼ @ .04
" French "	.06¼ @ .06½

WHILE Pennsylvania petroleum yields 70 per cent. of kerosene with a large residum of lubricating oil, the Caspian product yields but 28 per cent. of kerosene, with a refuse fit only for fuel. In the early days of Caspian petroleum its price was $2.00 per barrel. Now it often sells at ten cents. Twelve thousand square miles in Southern Russia have been proved to be oleiferous, and of this vast surface only six miles are, as yet, developed. The oil-bearing stratum is found to extend beneath the Caspian Sea, where it crops up in Tcheliken, a true isle of oil, which literally streams into the sea from hills and cliffs, which are entirely formed of crude paraffine.